Time Traveler (Group 5) Final Project - Demand Forecasting Using Seasonal ARIMA: Model Fit and Forecast Accuracy.

Youngjae Cho

2025-04-23 ~ 2025-05-01, 2025-05-05 ~ 2025-05-07, 2025-05-08 ~ 2025-05-10

```
## Purpose:
## In Milestone 1, at the last printed R result, we have seen the seasonality.
## In this Milestone 2, I will use range-mean plot to check the transformation and iden() function to
## check the stationarity for 4 differencing schemes.
## First off, I will load the data set and build the original time series plot that used in Milestone 1
miles2 <- read.csv("Daily Demand Forecasting Orders.csv") # Data source.
miles2
```

```
##     X Week.of.the.month..first.week..second..third..fourth.or.fifth.week
## 1   0                                                                   1
## 2   1                                                                   1
## 3   2                                                                   1
## 4   3                                                                   2
## 5   4                                                                   2
## 6   5                                                                   2
## 7   6                                                                   2
## 8   7                                                                   2
## 9   8                                                                   3
## 10  9                                                                   3
## 11 10                                                                   3
## 12 11                                                                   3
## 13 12                                                                   3
## 14 13                                                                   4
## 15 14                                                                   4
## 16 15                                                                   4
## 17 16                                                                   4
## 18 17                                                                   4
## 19 18                                                                   5
## 20 19                                                                   1
## 21 20                                                                   1
## 22 21                                                                   1
## 23 22                                                                   1
## 24 23                                                                   2
## 25 24                                                                   2
## 26 25                                                                   2
## 27 26                                                                   2
## 28 27                                                                   2
## 29 28                                                                   3
## 30 29                                                                   3
## 31 30                                                                   3
```

```
## 32 31                                                                    3
## 33 32                                                                    4
## 34 33                                                                    4
## 35 34                                                                    4
## 36 35                                                                    4
## 37 36                                                                    5
## 38 37                                                                    5
## 39 38                                                                    5
## 40 39                                                                    1
## 41 40                                                                    2
## 42 41                                                                    2
## 43 42                                                                    2
## 44 43                                                                    2
## 45 44                                                                    2
## 46 45                                                                    3
## 47 46                                                                    3
## 48 47                                                                    3
## 49 48                                                                    3
## 50 49                                                                    3
## 51 50                                                                    4
## 52 51                                                                    4
## 53 52                                                                    4
## 54 53                                                                    4
## 55 54                                                                    4
## 56 55                                                                    5
## 57 56                                                                    5
## 58 57                                                                    5
## 59 58                                                                    5
## 60 59                                                                    5
##    Day.of.the.week..Monday.to.Friday. Non.urgent.order Urgent.order
## 1                                   4          316.307      223.270
## 2                                   5          128.633       96.042
## 3                                   6           43.651       84.375
## 4                                   2          171.297      127.667
## 5                                   3           90.532      113.526
## 6                                   4          110.925       96.360
## 7                                   5          144.124      118.919
## 8                                   6          119.379      113.870
## 9                                   2          218.856      124.381
## 10                                  3          146.518      101.045
## 11                                  4          178.433      102.793
## 12                                  5          145.865       91.180
## 13                                  6          170.566      114.412
## 14                                  2          220.343      141.406
## 15                                  3          193.768      141.854
## 16                                  4          122.736      124.256
## 17                                  5          144.051      158.408
## 18                                  6          105.415      108.688
## 19                                  2          240.660      163.720
## 20                                  3          131.067      166.649
## 21                                  4          130.129       98.927
## 22                                  5          123.286      103.551
## 23                                  6          190.816       87.629
## 24                                  2          266.741      141.437
```

```
## 25                                    3          123.143      106.083
## 26                                    4          148.139       85.310
## 27                                    5          118.552      100.417
## 28                                    6          146.959       95.153
## 29                                    2          299.770      133.375
## 30                                    3          151.341      131.788
## 31                                    4          206.206       92.160
## 32                                    5          170.868      131.463
## 33                                    3          435.304      181.149
## 34                                    4          235.106      110.874
## 35                                    5          168.179      125.119
## 36                                    6          172.783       77.371
## 37                                    2          381.768      140.041
## 38                                    3          221.438      111.392
## 39                                    4          193.957      111.859
## 40                                    6          275.076      121.697
## 41                                    2          252.298      150.708
## 42                                    3          165.472      102.530
## 43                                    4          126.030      108.055
## 44                                    5          112.246      106.641
## 45                                    6          123.302       94.315
## 46                                    2          187.810      167.455
## 47                                    3          119.863      139.383
## 48                                    4          127.805      114.813
## 49                                    5          120.629      112.703
## 50                                    6          130.465      105.273
## 51                                    2          222.282      120.324
## 52                                    3          150.257      116.959
## 53                                    4           96.494       87.294
## 54                                    5           89.526       99.756
## 55                                    6          134.425       79.084
## 56                                    2          158.716      158.133
## 57                                    3          150.784      133.069
## 58                                    4          193.534      109.639
## 59                                    5          196.555      108.395
## 60                                    6          192.116      121.106
##    Order.type.A Order.type.B Order.type.C Fiscal.sector.orders
## 1        61.543      175.586      302.448                0.000
## 2        38.058       56.037      130.580                0.000
## 3        21.826       25.125       82.461                1.386
## 4        41.542      113.294      162.284               18.156
## 5        37.679       56.618      116.220                6.459
## 6        30.792       50.704      125.868               79.000
## 7        43.304       66.371      153.368                0.000
## 8        38.584       85.961      124.413               15.709
## 9        33.973      148.274      162.044                1.054
## 10       36.399       43.306      168.723              865.000
## 11       45.706      111.036      124.678              194.000
## 12       43.851       66.277      133.440                6.523
## 13       43.339      136.434      128.405               23.200
## 14       46.241      120.865      196.296                1.653
## 15       56.519      136.709      143.644                1.250
## 16       56.167       78.101      112.724                0.000
## 17       51.660       92.272      164.948                6.421
```

```
## 18       47.717       71.474      113.935              19.023
## 19       59.135      157.681      187.564               0.000
## 20       90.476       80.509      127.575             844.000
## 21       42.904       43.962      142.383             193.000
## 22       47.331       72.444      116.529               9.467
## 23       32.077      127.358      137.739              18.729
## 24       58.721      139.034      211.646               1.223
## 25       36.017       75.813      119.205               1.809
## 26       35.576       79.997      123.253               5.377
## 27       54.401       75.613      105.584              16.629
## 28       37.656       59.907      144.549               0.000
## 29       57.810      236.248      196.732              57.645
## 30       43.359       89.382      156.916               6.528
## 31       45.555      148.718      104.186              93.000
## 32       45.550      120.548      157.505              21.272
## 33       67.884      267.342      281.227               0.000
## 34       70.376      154.242      121.417              55.000
## 35       71.068      100.544      136.033              14.347
## 36       64.137      109.062       80.648               3.693
## 37      118.178      260.632      152.134               9.135
## 38       51.199      124.660      157.500             529.000
## 39       47.002       99.892      159.462             540.000
## 40      109.888      131.165      175.777              20.057
## 41       77.388      154.863      182.936              12.181
## 42       46.295       96.870      124.837               0.000
## 43       53.366       69.150      111.987             418.000
## 44       47.399       77.610      109.715              15.837
## 45       48.081       72.826      109.157              12.447
## 46       59.042      130.098      168.254               2.129
## 47       44.809       99.072      115.365               0.000
## 48       39.025      110.740       94.470               1.617
## 49       39.600      240.922      122.085             169.275
## 50       57.467       88.462      109.132              19.323
## 51       41.418      135.189      165.999               0.000
## 52       34.193      115.536      118.911               1.424
## 53       32.653       81.576       74.372               4.813
## 54       51.985       51.930       98.107              12.740
## 55       36.748       71.353      105.408               0.000
## 56       59.131       92.639      165.079               0.000
## 57       54.224      115.746      116.442               2.559
## 58       58.378      142.382      102.687             274.000
## 59       76.763       96.478      131.709               0.000
## 60      107.568      121.152      103.180              18.678
##    Orders.from.the.traffic.controller.sector Banking.orders..1.
## 1                                      65556              44914
## 2                                      40419              21399
## 3                                      11992               3452
## 4                                      49971              33703
## 5                                      48534              19646
## 6                                      52042               8773
## 7                                      46573              33597
## 8                                      35033              26278
## 9                                      66612              19461
## 10                                     58224               7742
```

```
## 11                                  47046              17299
## 12                                  66910              17768
## 13                                  32529              34002
## 14                                  34878              32905
## 15                                  57858              23956
## 16                                  52321              10046
## 17                                  47167               6440
## 18                                  42737              26020
## 19                                  39273              32917
## 20                                  60543              19141
## 21                                  54760               9163
## 22                                  48732              21196
## 23                                  46368              36798
## 24                                  58081              43333
## 25                                  45340              22109
## 26                                  59686              14188
## 27                                  40423              24682
## 28                                  50908              45733
## 29                                  71772              57756
## 30                                  53573              42638
## 31                                  49110              36904
## 32                                  42534              79556
## 33                                  64867             210508
## 34                                  23257             163452
## 35                                  28072              95989
## 36                                  46321              66498
## 37                                  34236             194216
## 38                                  39964             136119
## 39                                  59179              94460
## 40                                  37906             138536
## 41                                  32133              69093
## 42                                  48458              43112
## 43                                  42201              13736
## 44                                  35316              25876
## 45                                  43284              30138
## 46                                  37817              36445
## 47                                  54584              17242
## 48                                  33366              21103
## 49                                  37387              20246
## 50                                  27200              41713
## 51                                  39446              29290
## 52                                  51346              19782
## 53                                  34631              22420
## 54                                  31850              32150
## 55                                  33970              28701
## 56                                  32027              33282
## 57                                  51235              34421
## 58                                  28364              88404
## 59                                  37011             109931
## 60                                  27328             108072
##    Banking.orders..2. Banking.orders..3. Target..Total.orders.
## 1              188411              14793               539.577
## 2               89461               7679               224.675
## 3               21305              14947               129.412
```

```
## 4          69054          18423          317.120
## 5          16411          20257          210.517
## 6          47522          24966          207.364
## 7          48269          20973          263.043
## 8          56665          18502          248.958
## 9         103376          10458          344.291
## 10         82395          11948          248.428
## 11        108719          15560          281.420
## 12         36693          29046          243.568
## 13         78153          31949          308.178
## 14        117137          29188          363.402
## 15        101048          30134          336.872
## 16         62799          24233          246.992
## 17         91784          15973          308.880
## 18         27873          17600          233.126
## 19        155617           9203          404.380
## 20         78378          73839          298.560
## 21         29874          46992          229.249
## 22         47793          47574          236.304
## 23         92701          31098          297.174
## 24        135314          29716          409.401
## 25         55584          29803          231.035
## 26         67617          32319          238.826
## 27         47563          35314          235.598
## 28         43930          28998          242.112
## 29        159373          29160          490.790
## 30         62732          32386          289.657
## 31        126632          33237          298.459
## 32         50433          36483          323.603
## 33        177229          30514          616.453
## 34         63699          33805          346.035
## 35         50763          55445          307.645
## 36         61593          31625          253.847
## 37        136035          47601          530.944
## 38         66745          31031          333.359
## 39         54772          34616          306.356
## 40         85378          14020          416.830
## 41        169088          12516          415.187
## 42         72840          11304          268.002
## 43         70191          16710          234.503
## 44         38646          13989          234.724
## 45         52112          12632          230.064
## 46        103567          10443          357.394
## 47         59231          12543          259.246
## 48         84558          16683          244.235
## 49         63778          13886          402.607
## 50         59513          12260          255.061
## 51        154144          10811          342.606
## 52         89704          12182          268.640
## 53         49644          15390          188.601
## 54         21573          13807          202.022
## 55         65199          11023          213.509
## 56        128269           9287          316.849
## 57         87708          11354          286.412
```

```
## 58              91367              15003              303.447
## 59              50112              12957              304.950
## 60              56015              10690              331.900
```

```
# For seeing the first few rows to check.
head(miles2)
```

```
##   X Week.of.the.month..first.week..second..third..fourth.or.fifth.week
## 1 0                                                                   1
## 2 1                                                                   1
## 3 2                                                                   1
## 4 3                                                                   2
## 5 4                                                                   2
## 6 5                                                                   2
##   Day.of.the.week..Monday.to.Friday. Non.urgent.order Urgent.order Order.type.A
## 1                                  4          316.307      223.270       61.543
## 2                                  5          128.633       96.042       38.058
## 3                                  6           43.651       84.375       21.826
## 4                                  2          171.297      127.667       41.542
## 5                                  3           90.532      113.526       37.679
## 6                                  4          110.925       96.360       30.792
##   Order.type.B Order.type.C Fiscal.sector.orders
## 1      175.586      302.448                0.000
## 2       56.037      130.580                0.000
## 3       25.125       82.461                1.386
## 4      113.294      162.284               18.156
## 5       56.618      116.220                6.459
## 6       50.704      125.868               79.000
##   Orders.from.the.traffic.controller.sector Banking.orders..1.
## 1                                     65556              44914
## 2                                     40419              21399
## 3                                     11992               3452
## 4                                     49971              33703
## 5                                     48534              19646
## 6                                     52042               8773
##   Banking.orders..2. Banking.orders..3. Target..Total.orders.
## 1             188411              14793               539.577
## 2              89461               7679               224.675
## 3              21305              14947               129.412
## 4              69054              18423               317.120
## 5              16411              20257               210.517
## 6              47522              24966               207.364
```

```
# To check the column for variables.
colnames(miles2)
```

```
##  [1] "X"
##  [2] "Week.of.the.month..first.week..second..third..fourth.or.fifth.week"
##  [3] "Day.of.the.week..Monday.to.Friday."
##  [4] "Non.urgent.order"
##  [5] "Urgent.order"
##  [6] "Order.type.A"
##  [7] "Order.type.B"
```

```
##  [8] "Order.type.C"
##  [9] "Fiscal.sector.orders"
## [10] "Orders.from.the.traffic.controller.sector"
## [11] "Banking.orders..1."
## [12] "Banking.orders..2."
## [13] "Banking.orders..3."
## [14] "Target..Total.orders."
```

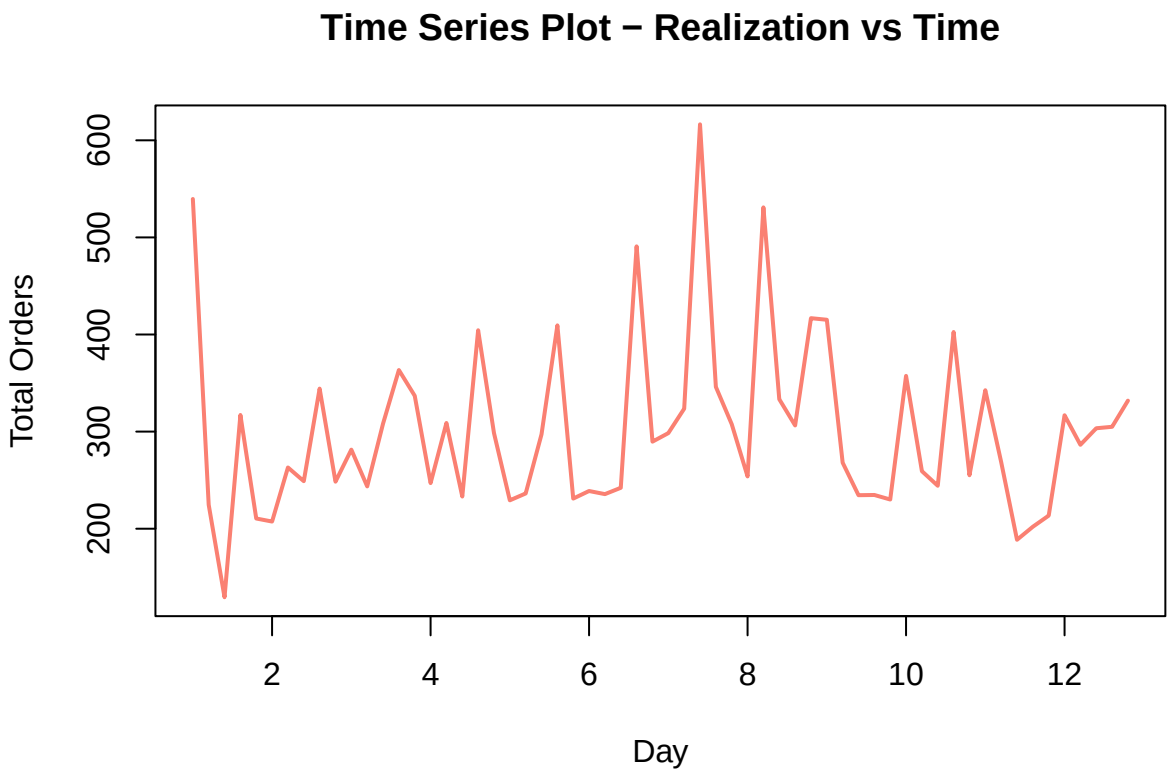
```
# To generate a sequential time index
miles2$time_index <- seq(from=1, to = nrow(miles2), by =1)
miles2$time_index
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
## [26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
## [51] 51 52 53 54 55 56 57 58 59 60
```

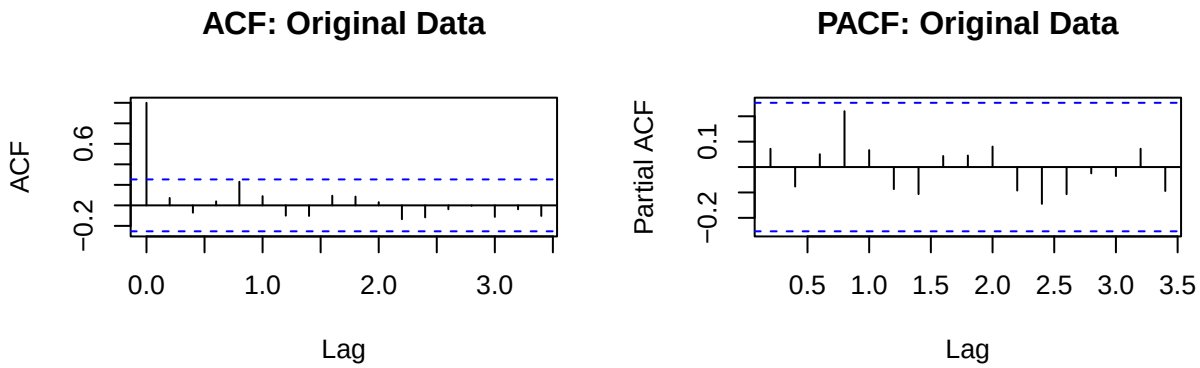
```
# Select the total orders variables.
miles2_ts <- ts(miles2$Target..Total.orders., frequency = 5) # Weekly frequency for 5 business days.
miles2_ts # Start from 1 to 60.
```

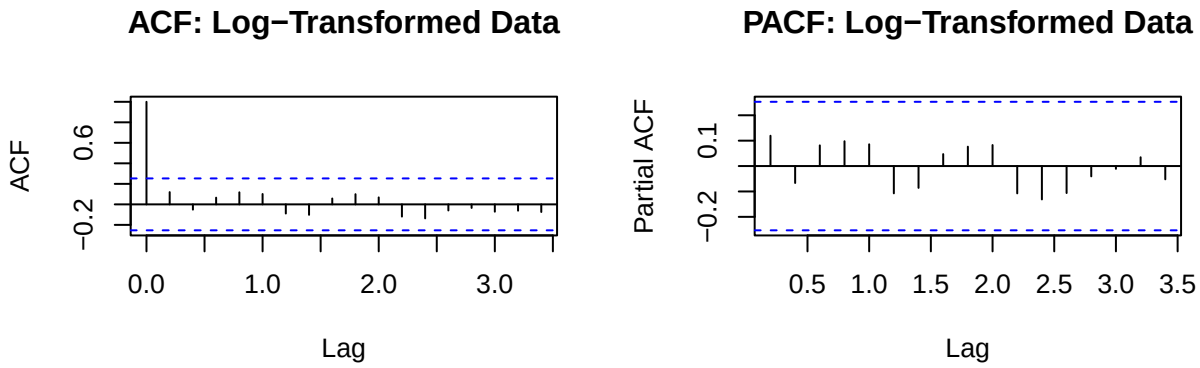
```
## Time Series:
## Start = c(1, 1)
## End = c(12, 5)
## Frequency = 5
##  [1] 539.577 224.675 129.412 317.120 210.517 207.364 263.043 248.958 344.291
## [10] 248.428 281.420 243.568 308.178 363.402 336.872 246.992 308.880 233.126
## [19] 404.380 298.560 229.249 236.304 297.174 409.401 231.035 238.826 235.598
## [28] 242.112 490.790 289.657 298.459 323.603 616.453 346.035 307.645 253.847
## [37] 530.944 333.359 306.356 416.830 415.187 268.002 234.503 234.724 230.064
## [46] 357.394 259.246 244.235 402.607 255.061 342.606 268.640 188.601 202.022
## [55] 213.509 316.849 286.412 303.447 304.950 331.900
```

```
# Time Series Plot.
plot(miles2_ts, type="l", col="salmon", lwd=2,
     main = "Time Series Plot - Realization vs Time",
     xlab = "Day", ylab = "Total Orders")
```




```r
## In this Milestone2, the time series plot between Realization and Time, we can see the seasonality.
## Therefore, I will use s = 5 for five business days, that is weekly cycles, Monday to Friday.
## I will use acf, pacf plots after log-transformation.

# Base functions for ACF & PACF comparison
par(mfrow=c(2,2))

# ACF & PACF plots for original time series data.
acf(miles2_ts, main="ACF: Original Data")
pacf(miles2_ts, main="PACF: Original Data")

# Log-transformed data
log_miles2_ts <- log(miles2_ts)

# ACF & PACF plots of log-transformed data
acf(log(miles2_ts), main="ACF: Log-Transformed Data")
pacf(log(miles2_ts), main="PACF: Log-Transformed Data") # No need for transformation.
```






```
par(mfrow=c(1,1))
```

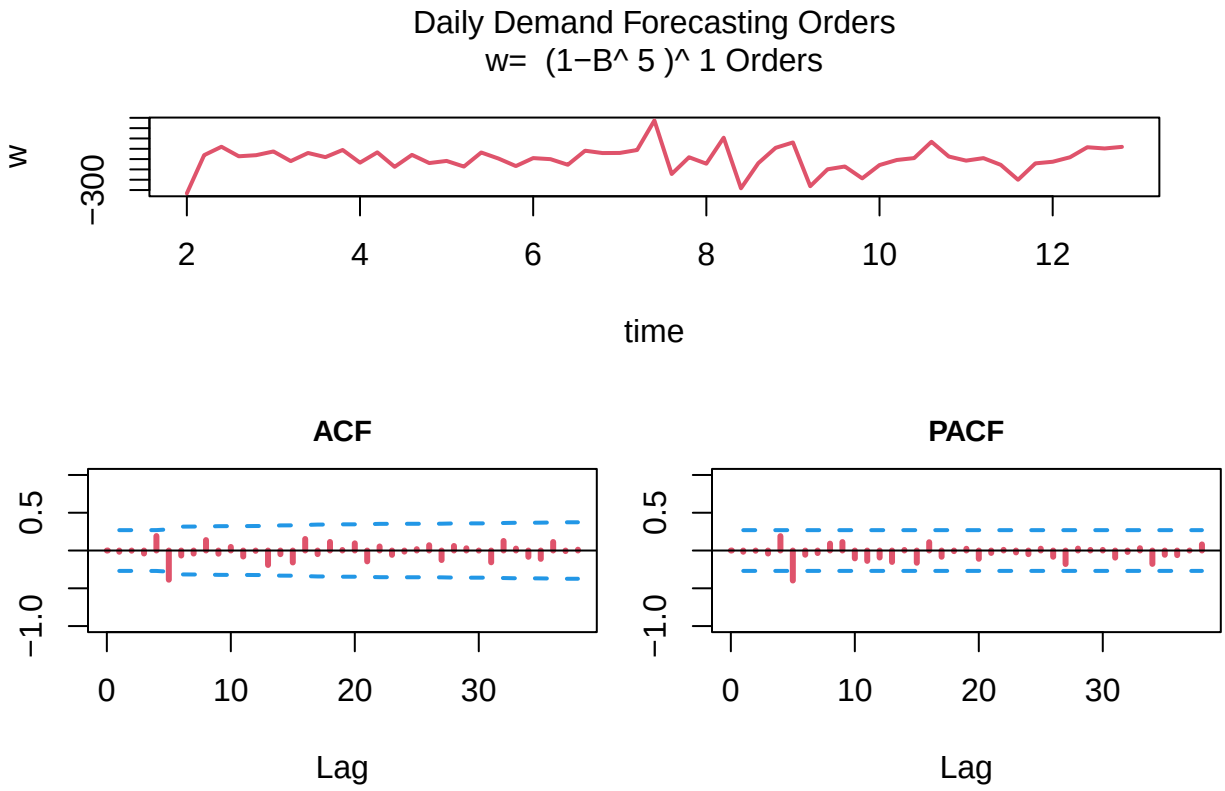
```
## Then, I will use iden() function to check the stationary.
# Run the Seasonal identification with two different differencing schemes.
miles2_tsd <- tsd(miles2_ts,
                  data.title = "Daily Demand Forecasting Orders",
                  response.units = "Orders",
                  time.units = "Day")
miles2_tsd
```

```
## Time Series:
## Start = c(1, 1)
## End = c(12, 5)
## Frequency = 5
##  [1] 539.577 224.675 129.412 317.120 210.517 207.364 263.043 248.958 344.291
## [10] 248.428 281.420 243.568 308.178 363.402 336.872 246.992 308.880 233.126
## [19] 404.380 298.560 229.249 236.304 297.174 409.401 231.035 238.826 235.598
## [28] 242.112 490.790 289.657 298.459 323.603 616.453 346.035 307.645 253.847
## [37] 530.944 333.359 306.356 416.830 415.187 268.002 234.503 234.724 230.064
## [46] 357.394 259.246 244.235 402.607 255.061 342.606 268.640 188.601 202.022
## [55] 213.509 316.849 286.412 303.447 304.950 331.900
## attr(,"time.units")
## [1] Day
## attr(,"data.title")
## [1] Daily Demand Forecasting Orders
```

```
## attr(,"response.units")
## [1] Orders
```

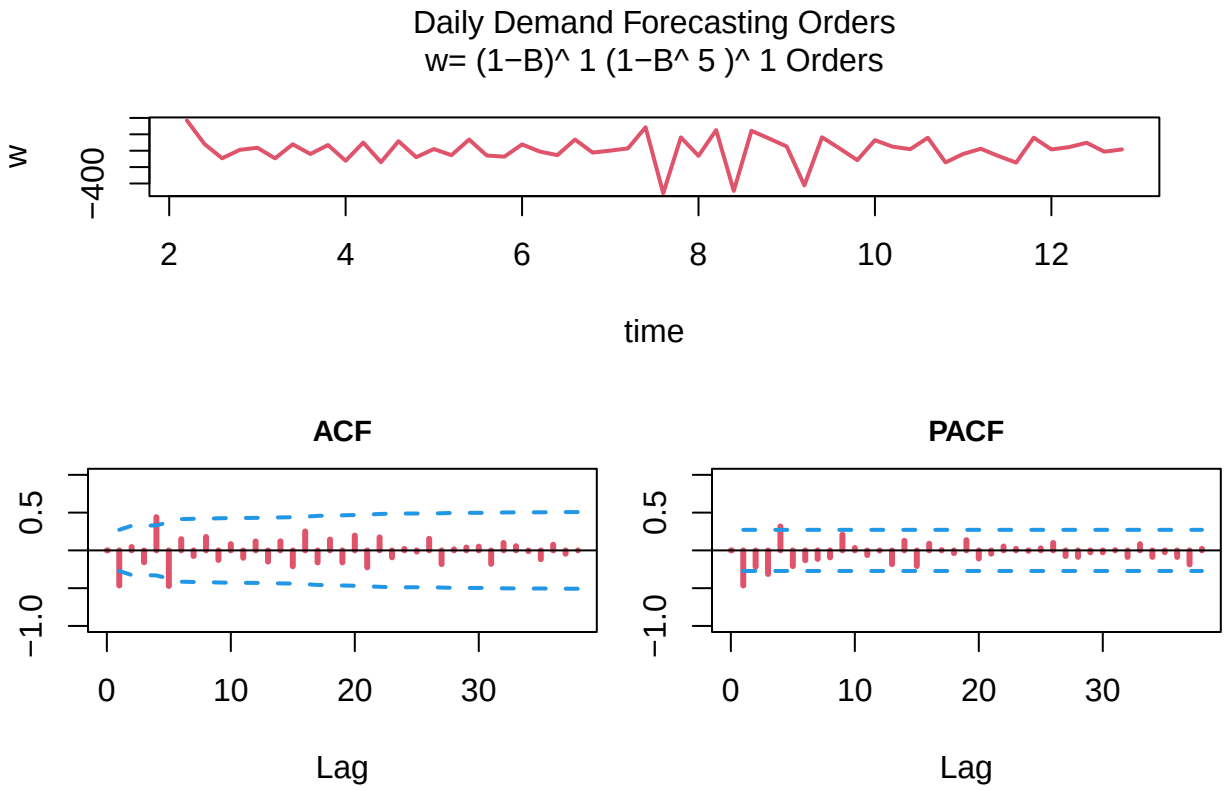
```
# iden function for only two differencing in seasonal time series.
iden(miles2_tsd, d = 0, D = 1) # Seasonal only.
```

```
## Identification Output for Daily Demand Forecasting Orders
## w=  (1-B^ 5 )^ 1 Orders

## Standard deviation of the working series= 89.60204
```




```
iden(miles2_tsd, d = 1, D = 1) # First order and seasonal but it would be over-differencing.
```

```
## Identification Output for Daily Demand Forecasting Orders
## w= (1-B)^ 1 (1-B^ 5 )^ 1 Orders

## Standard deviation of the working series= 89.60204
```



#4. Library setting

```
library(forecast)
```

```
## Warning:    'forecast'  R    4.4.2
```

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

```
library(TSA)
```

```
## Warning:    'TSA'  R    4.4.3
```

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

```
##
##          : 'TSA'
```

```
## The following object is masked from 'package:RTseries':
##
##     prewhiten
```

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

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

```
library(tseries)
```

```
## Warning:    'tseries'  R   4.4.2
```

#5. Do ADF Test for getting Stationary and fit four candidate SARIMA Models. (5/5)

(0, 0, 2)(1, 0, 1)_5, residual analysis, forecast are needed for further steps.

Interpretation:

After adf test, I got p-value of 0.01 from the (d=1, D=1) differenced series. The p-value was smaller than the signficance level so we can reject the null hypothesis. In conclusion, the series is stationary after conducting the first and seasonal differencing. For this part: Fit 2 has larger AIC, BIC than other fit models. Therefore, I decide fit2 for model selection.

```
# data
data <- read.csv("Daily Demand Forecasting Orders.csv")
ts_data <- ts(data$Target..Total.orders., frequency = 5) # For weekly seasonality.

print(data)
```

```
##     X Week.of.the.month..first.week..second..third..fourth.or.fifth.week
## 1   0                                                                   1
## 2   1                                                                   1
## 3   2                                                                   1
## 4   3                                                                   2
## 5   4                                                                   2
## 6   5                                                                   2
## 7   6                                                                   2
## 8   7                                                                   2
## 9   8                                                                   3
## 10  9                                                                   3
## 11 10                                                                   3
## 12 11                                                                   3
## 13 12                                                                   3
## 14 13                                                                   4
## 15 14                                                                   4
## 16 15                                                                   4
## 17 16                                                                   4
## 18 17                                                                   4
```

```
## 19 18                                                                    5
## 20 19                                                                    1
## 21 20                                                                    1
## 22 21                                                                    1
## 23 22                                                                    1
## 24 23                                                                    2
## 25 24                                                                    2
## 26 25                                                                    2
## 27 26                                                                    2
## 28 27                                                                    2
## 29 28                                                                    3
## 30 29                                                                    3
## 31 30                                                                    3
## 32 31                                                                    3
## 33 32                                                                    4
## 34 33                                                                    4
## 35 34                                                                    4
## 36 35                                                                    4
## 37 36                                                                    5
## 38 37                                                                    5
## 39 38                                                                    5
## 40 39                                                                    1
## 41 40                                                                    2
## 42 41                                                                    2
## 43 42                                                                    2
## 44 43                                                                    2
## 45 44                                                                    2
## 46 45                                                                    3
## 47 46                                                                    3
## 48 47                                                                    3
## 49 48                                                                    3
## 50 49                                                                    3
## 51 50                                                                    4
## 52 51                                                                    4
## 53 52                                                                    4
## 54 53                                                                    4
## 55 54                                                                    4
## 56 55                                                                    5
## 57 56                                                                    5
## 58 57                                                                    5
## 59 58                                                                    5
## 60 59                                                                    5
##    Day.of.the.week..Monday.to.Friday. Non.urgent.order Urgent.order
## 1                                   4          316.307      223.270
## 2                                   5          128.633       96.042
## 3                                   6           43.651       84.375
## 4                                   2          171.297      127.667
## 5                                   3           90.532      113.526
## 6                                   4          110.925       96.360
## 7                                   5          144.124      118.919
## 8                                   6          119.379      113.870
## 9                                   2          218.856      124.381
## 10                                  3          146.518      101.045
## 11                                  4          178.433      102.793
```

```
## 12                                  5          145.865       91.180
## 13                                  6          170.566      114.412
## 14                                  2          220.343      141.406
## 15                                  3          193.768      141.854
## 16                                  4          122.736      124.256
## 17                                  5          144.051      158.408
## 18                                  6          105.415      108.688
## 19                                  2          240.660      163.720
## 20                                  3          131.067      166.649
## 21                                  4          130.129       98.927
## 22                                  5          123.286      103.551
## 23                                  6          190.816       87.629
## 24                                  2          266.741      141.437
## 25                                  3          123.143      106.083
## 26                                  4          148.139       85.310
## 27                                  5          118.552      100.417
## 28                                  6          146.959       95.153
## 29                                  2          299.770      133.375
## 30                                  3          151.341      131.788
## 31                                  4          206.206       92.160
## 32                                  5          170.868      131.463
## 33                                  3          435.304      181.149
## 34                                  4          235.106      110.874
## 35                                  5          168.179      125.119
## 36                                  6          172.783       77.371
## 37                                  2          381.768      140.041
## 38                                  3          221.438      111.392
## 39                                  4          193.957      111.859
## 40                                  6          275.076      121.697
## 41                                  2          252.298      150.708
## 42                                  3          165.472      102.530
## 43                                  4          126.030      108.055
## 44                                  5          112.246      106.641
## 45                                  6          123.302       94.315
## 46                                  2          187.810      167.455
## 47                                  3          119.863      139.383
## 48                                  4          127.805      114.813
## 49                                  5          120.629      112.703
## 50                                  6          130.465      105.273
## 51                                  2          222.282      120.324
## 52                                  3          150.257      116.959
## 53                                  4           96.494       87.294
## 54                                  5           89.526       99.756
## 55                                  6          134.425       79.084
## 56                                  2          158.716      158.133
## 57                                  3          150.784      133.069
## 58                                  4          193.534      109.639
## 59                                  5          196.555      108.395
## 60                                  6          192.116      121.106
##    Order.type.A Order.type.B Order.type.C Fiscal.sector.orders
## 1        61.543      175.586      302.448                0.000
## 2        38.058       56.037      130.580                0.000
## 3        21.826       25.125       82.461                1.386
## 4        41.542      113.294      162.284               18.156
```

```
## 5       37.679       56.618      116.220              6.459
## 6       30.792       50.704      125.868             79.000
## 7       43.304       66.371      153.368              0.000
## 8       38.584       85.961      124.413             15.709
## 9       33.973      148.274      162.044              1.054
## 10      36.399       43.306      168.723            865.000
## 11      45.706      111.036      124.678            194.000
## 12      43.851       66.277      133.440              6.523
## 13      43.339      136.434      128.405             23.200
## 14      46.241      120.865      196.296              1.653
## 15      56.519      136.709      143.644              1.250
## 16      56.167       78.101      112.724              0.000
## 17      51.660       92.272      164.948              6.421
## 18      47.717       71.474      113.935             19.023
## 19      59.135      157.681      187.564              0.000
## 20      90.476       80.509      127.575            844.000
## 21      42.904       43.962      142.383            193.000
## 22      47.331       72.444      116.529              9.467
## 23      32.077      127.358      137.739             18.729
## 24      58.721      139.034      211.646              1.223
## 25      36.017       75.813      119.205              1.809
## 26      35.576       79.997      123.253              5.377
## 27      54.401       75.613      105.584             16.629
## 28      37.656       59.907      144.549              0.000
## 29      57.810      236.248      196.732             57.645
## 30      43.359       89.382      156.916              6.528
## 31      45.555      148.718      104.186             93.000
## 32      45.550      120.548      157.505             21.272
## 33      67.884      267.342      281.227              0.000
## 34      70.376      154.242      121.417             55.000
## 35      71.068      100.544      136.033             14.347
## 36      64.137      109.062       80.648              3.693
## 37     118.178      260.632      152.134              9.135
## 38      51.199      124.660      157.500            529.000
## 39      47.002       99.892      159.462            540.000
## 40     109.888      131.165      175.777             20.057
## 41      77.388      154.863      182.936             12.181
## 42      46.295       96.870      124.837              0.000
## 43      53.366       69.150      111.987            418.000
## 44      47.399       77.610      109.715             15.837
## 45      48.081       72.826      109.157             12.447
## 46      59.042      130.098      168.254              2.129
## 47      44.809       99.072      115.365              0.000
## 48      39.025      110.740       94.470              1.617
## 49      39.600      240.922      122.085            169.275
## 50      57.467       88.462      109.132             19.323
## 51      41.418      135.189      165.999              0.000
## 52      34.193      115.536      118.911              1.424
## 53      32.653       81.576       74.372              4.813
## 54      51.985       51.930       98.107             12.740
## 55      36.748       71.353      105.408              0.000
## 56      59.131       92.639      165.079              0.000
## 57      54.224      115.746      116.442              2.559
## 58      58.378      142.382      102.687            274.000
```

```
## 59       76.763       96.478      131.709               0.000
## 60      107.568      121.152      103.180              18.678
##    Orders.from.the.traffic.controller.sector Banking.orders..1.
## 1                                      65556               44914
## 2                                      40419               21399
## 3                                      11992                3452
## 4                                      49971               33703
## 5                                      48534               19646
## 6                                      52042                8773
## 7                                      46573               33597
## 8                                      35033               26278
## 9                                      66612               19461
## 10                                     58224                7742
## 11                                     47046               17299
## 12                                     66910               17768
## 13                                     32529               34002
## 14                                     34878               32905
## 15                                     57858               23956
## 16                                     52321               10046
## 17                                     47167                6440
## 18                                     42737               26020
## 19                                     39273               32917
## 20                                     60543               19141
## 21                                     54760                9163
## 22                                     48732               21196
## 23                                     46368               36798
## 24                                     58081               43333
## 25                                     45340               22109
## 26                                     59686               14188
## 27                                     40423               24682
## 28                                     50908               45733
## 29                                     71772               57756
## 30                                     53573               42638
## 31                                     49110               36904
## 32                                     42534               79556
## 33                                     64867              210508
## 34                                     23257              163452
## 35                                     28072               95989
## 36                                     46321               66498
## 37                                     34236              194216
## 38                                     39964              136119
## 39                                     59179               94460
## 40                                     37906              138536
## 41                                     32133               69093
## 42                                     48458               43112
## 43                                     42201               13736
## 44                                     35316               25876
## 45                                     43284               30138
## 46                                     37817               36445
## 47                                     54584               17242
## 48                                     33366               21103
## 49                                     37387               20246
## 50                                     27200               41713
## 51                                     39446               29290
```

```
## 52                                  51346              19782
## 53                                  34631              22420
## 54                                  31850              32150
## 55                                  33970              28701
## 56                                  32027              33282
## 57                                  51235              34421
## 58                                  28364              88404
## 59                                  37011             109931
## 60                                  27328             108072
##    Banking.orders..2. Banking.orders..3. Target..Total.orders.
## 1              188411              14793                539.577
## 2               89461               7679                224.675
## 3               21305              14947                129.412
## 4               69054              18423                317.120
## 5               16411              20257                210.517
## 6               47522              24966                207.364
## 7               48269              20973                263.043
## 8               56665              18502                248.958
## 9              103376              10458                344.291
## 10              82395              11948                248.428
## 11             108719              15560                281.420
## 12              36693              29046                243.568
## 13              78153              31949                308.178
## 14             117137              29188                363.402
## 15             101048              30134                336.872
## 16              62799              24233                246.992
## 17              91784              15973                308.880
## 18              27873              17600                233.126
## 19             155617               9203                404.380
## 20              78378              73839                298.560
## 21              29874              46992                229.249
## 22              47793              47574                236.304
## 23              92701              31098                297.174
## 24             135314              29716                409.401
## 25              55584              29803                231.035
## 26              67617              32319                238.826
## 27              47563              35314                235.598
## 28              43930              28998                242.112
## 29             159373              29160                490.790
## 30              62732              32386                289.657
## 31             126632              33237                298.459
## 32              50433              36483                323.603
## 33             177229              30514                616.453
## 34              63699              33805                346.035
## 35              50763              55445                307.645
## 36              61593              31625                253.847
## 37             136035              47601                530.944
## 38              66745              31031                333.359
## 39              54772              34616                306.356
## 40              85378              14020                416.830
## 41             169088              12516                415.187
## 42              72840              11304                268.002
## 43              70191              16710                234.503
## 44              38646              13989                234.724
```

```
## 45              52112              12632              230.064
## 46             103567              10443              357.394
## 47              59231              12543              259.246
## 48              84558              16683              244.235
## 49              63778              13886              402.607
## 50              59513              12260              255.061
## 51             154144              10811              342.606
## 52              89704              12182              268.640
## 53              49644              15390              188.601
## 54              21573              13807              202.022
## 55              65199              11023              213.509
## 56             128269               9287              316.849
## 57              87708              11354              286.412
## 58              91367              15003              303.447
## 59              50112              12957              304.950
## 60              56015              10690              331.900
```

```
print(ts_data)
```

```
## Time Series:
## Start = c(1, 1)
## End = c(12, 5)
## Frequency = 5
##  [1] 539.577 224.675 129.412 317.120 210.517 207.364 263.043 248.958 344.291
## [10] 248.428 281.420 243.568 308.178 363.402 336.872 246.992 308.880 233.126
## [19] 404.380 298.560 229.249 236.304 297.174 409.401 231.035 238.826 235.598
## [28] 242.112 490.790 289.657 298.459 323.603 616.453 346.035 307.645 253.847
## [37] 530.944 333.359 306.356 416.830 415.187 268.002 234.503 234.724 230.064
## [46] 357.394 259.246 244.235 402.607 255.061 342.606 268.640 188.601 202.022
## [55] 213.509 316.849 286.412 303.447 304.950 331.900
```

```
# ADF Tests for two differenced series
cat("ADF Test for Seasonal Differencing Only (d=0, D=1):\n") # No - Non-Stationary. (High p-value)
```

```
## ADF Test for Seasonal Differencing Only (d=0, D=1):
```

```
adf.test(diff(ts_data, lag = 5), alternative = "stationary")
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  diff(ts_data, lag = 5)
## Dickey-Fuller = -2.4647, Lag order = 3, p-value = 0.3873
## alternative hypothesis: stationary
```

```
cat("\nADF Test for First and Seasonal Differencing (d=1, D=1):\n") # Yes - Stationary Confirm! (small
```

```
##
## ADF Test for First and Seasonal Differencing (d=1, D=1):
```

```r
adf.test(diff(diff(ts_data), lag = 5), alternative = "stationary")
```

```
## Warning in adf.test(diff(diff(ts_data), lag = 5), alternative = "stationary"):
## p-value smaller than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  diff(diff(ts_data), lag = 5)
## Dickey-Fuller = -4.2731, Lag order = 3, p-value = 0.01
## alternative hypothesis: stationary
```

```r
# Fit four candidate SARIMA Models.
fit1 <- Arima(ts_data, order =c(0,1,1), seasonal= list(order =c(0,0,1), period= 5))
fit2 <- Arima(ts_data, order =c(1,1,1), seasonal= list(order =c(0,1,1), period= 5))
fit3 <- Arima(ts_data, order =c(0,1,2), seasonal= list(order =c(1,0,1), period = 5))
fit4 <- Arima(ts_data, order =c(0,0,2), seasonal= list(order =c(1,0,1), period= 5))

print(fit1)
```

```
## Series: ts_data
## ARIMA(0,1,1)(0,0,1)[5]
##
## Coefficients:
##           ma1    sma1
##       -1.0000  0.1090
## s.e.   0.0965  0.1293
##
## sigma^2 = 8232:  log likelihood = -350.65
## AIC=707.3   AICc=707.73   BIC=713.53
```

```r
print(fit2)
```

```
## Series: ts_data
## ARIMA(1,1,1)(0,1,1)[5]
##
## Coefficients:
##          ar1      ma1     sma1
##       0.0651  -0.8807  -0.9999
## s.e.  0.1779   0.1094   0.4402
##
## sigma^2 = 8967:  log likelihood = -328.31
## AIC=664.62   AICc=665.44   BIC=672.58
```

```r
print(fit3)
```

```
## Series: ts_data
## ARIMA(0,1,2)(1,0,1)[5]
##
## Coefficients:
```

```
##           ma1      ma2    sar1     sma1
##       -0.9047  -0.0953  0.2444  -0.1389
## s.e.   0.1660   0.1515  0.7523   0.7607
##
## sigma^2 = 8491:  log likelihood = -350.4
## AIC=710.8   AICc=711.93   BIC=721.19
```

```
print(fit4)
```

```
## Series: ts_data
## ARIMA(0,0,2)(1,0,1)[5] with non-zero mean
##
## Coefficients:
##          ma1      ma2    sar1     sma1      mean
##       0.0743  -0.0516  0.1591  -0.0759  300.9044
## s.e.  0.1380   0.1125  0.7992   0.8010   12.7173
##
## sigma^2 = 8458:  log likelihood = -353.84
## AIC=719.67   AICc=721.26   BIC=732.24
```

#6. Compare AIC and BIC.

Interpretation for 6.

Why the model 2 is the best fit? Why 4? First off, Model 2 AIC, BIC values are smaller than other models. Therefore, the model 2 is the best fit.

```
cat("Model 1 (0,1,1)(0,0,1)[5]:\n", "AIC:",AIC(fit1), "BIC:", BIC(fit1),"\n")
```

```
## Model 1 (0,1,1)(0,0,1)[5]:
##  AIC: 707.2969 BIC: 713.5296
```

```
cat("Model 2 (1,1,1)(0,1,1)[5]:\n", "AIC:",AIC(fit2), "BIC:", BIC(fit2),"\n")
```

```
## Model 2 (1,1,1)(0,1,1)[5]:
##  AIC: 664.6203 BIC: 672.5762
```

```
cat("Model 3 (0,1,2)(1,0,1)[5]:\n", "AIC:",AIC(fit3), "BIC:", BIC(fit3),"\n")
```

```
## Model 3 (0,1,2)(1,0,1)[5]:
##  AIC: 710.7982 BIC: 721.1859
```

```
cat("Model 4 (0,0,2)(1,0,1)[5]:\n", "AIC:",AIC(fit4), "BIC:", BIC(fit4),"\n")
```

```
## Model 4 (0,0,2)(1,0,1)[5]:
##  AIC: 719.6728 BIC: 732.2389
```

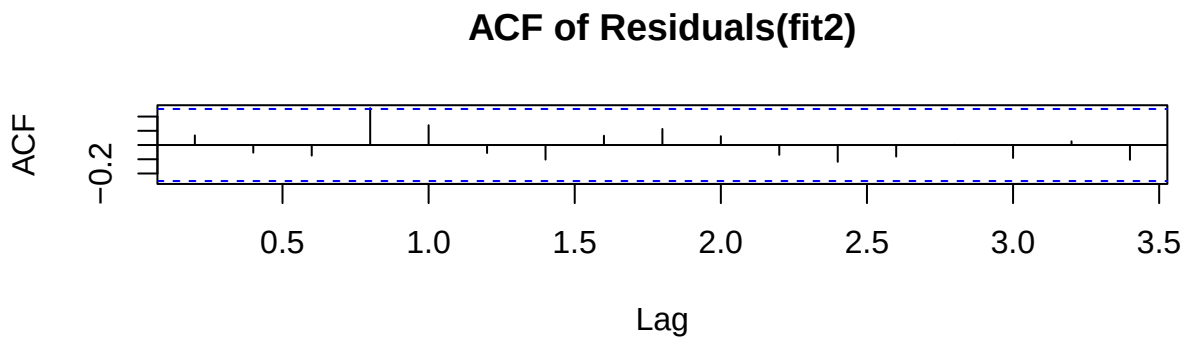
#7. Residual diagnostics for fit4 (SARIMA(0,0,2)(1,0,1)[5]) AND Fit2 (SARIMA(1,1,1)(0,1,1)[5])

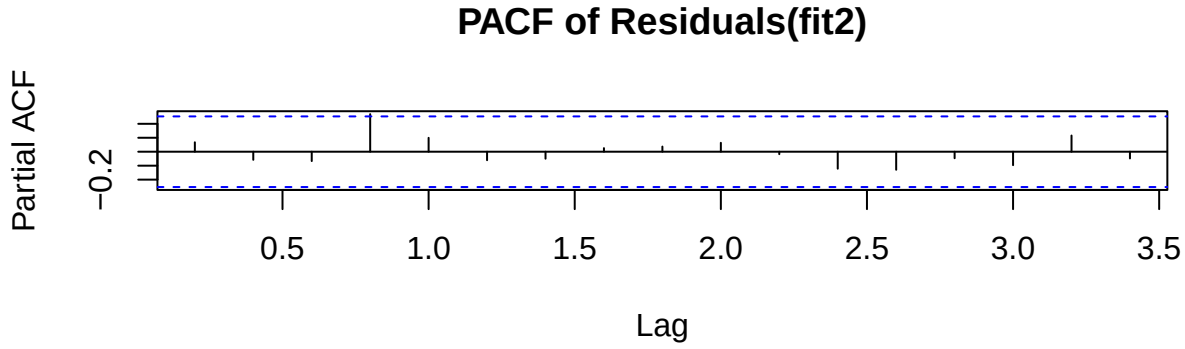
Interpretation:

I think Model 2(fit 2) is better to fit because the AIC, BIC values from fit2 are smaller than other 3 models. Reasons: - lower AIC, BIC values. - P-value was larger than significance level due to p-value = 0.2474. - Better generation for forecasting. - Most data was close to red line, so reasonable Q-Q normality. (But there were some outliers) - Proper differencing (d=1, D=1) for dealing with Stationarity. Conclusion: Model 2 is well-fitted and appropriate for SARIMA Model for this data set.

Model 4 has the highest AIC and BIC values and in the Normal Q-Q plot, it looks more skewed.

```
# Model 4, SARIMA(0,0,2)(1,0,1)[5] model for Residual Diagnostics.
# par(mfrow = c(2, 1))
# acf(residuals(fit4), main = "ACF of Residuals")
# pacf(residuals(fit4), main = "PACF of Residuals")
# par(mfrow = c(1, 1))

# Box.test(residuals(fit4), lag = 10, type = "Ljung-Box", fitdf = 3)  # df = 3.
# qqnorm(residuals(fit4)); qqline(residuals(fit4), col = "blue")

# Best Model: Model 2, SARIMA(1,1,1)(0,1,1)[5] model for Residual Diagnostics.
par(mfrow = c(2, 1))
acf(residuals(fit2), main = "ACF of Residuals(fit2)")
pacf(residuals(fit2), main = "PACF of Residuals(fit2)")
```

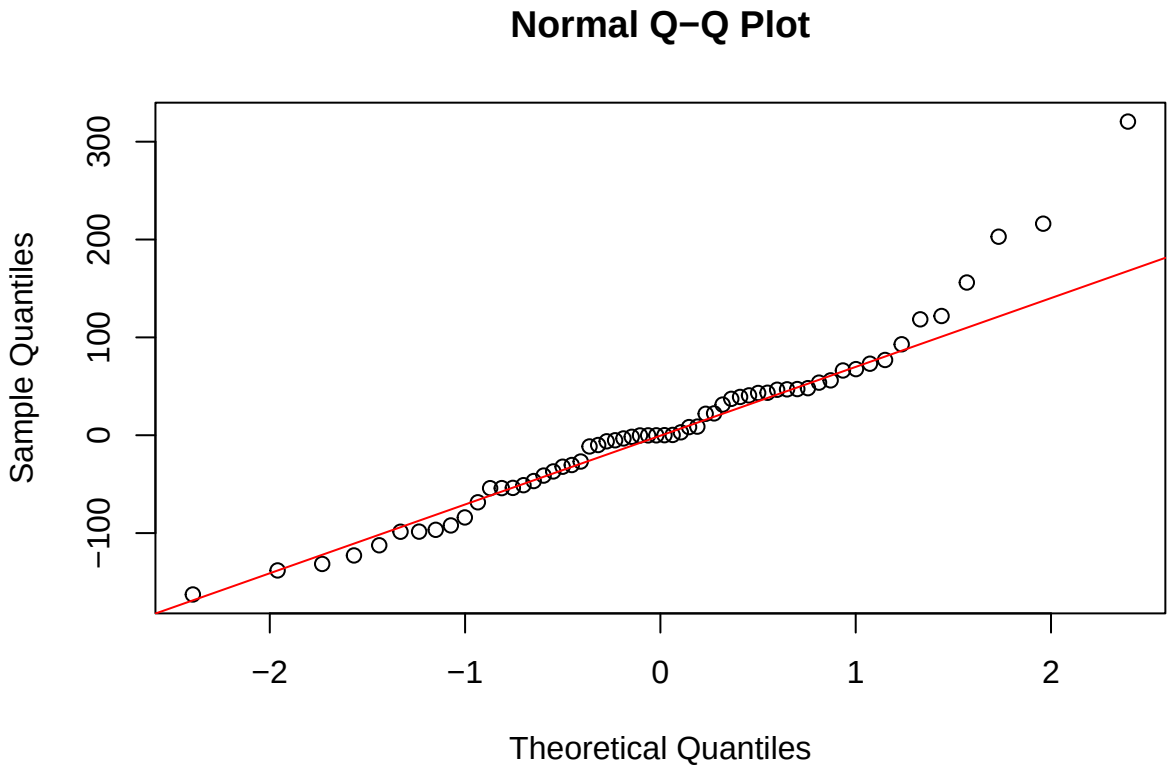




```r
par(mfrow = c(1, 1))

Box.test(residuals(fit2), lag = 10, type = "Ljung-Box", fitdf = 3)
```

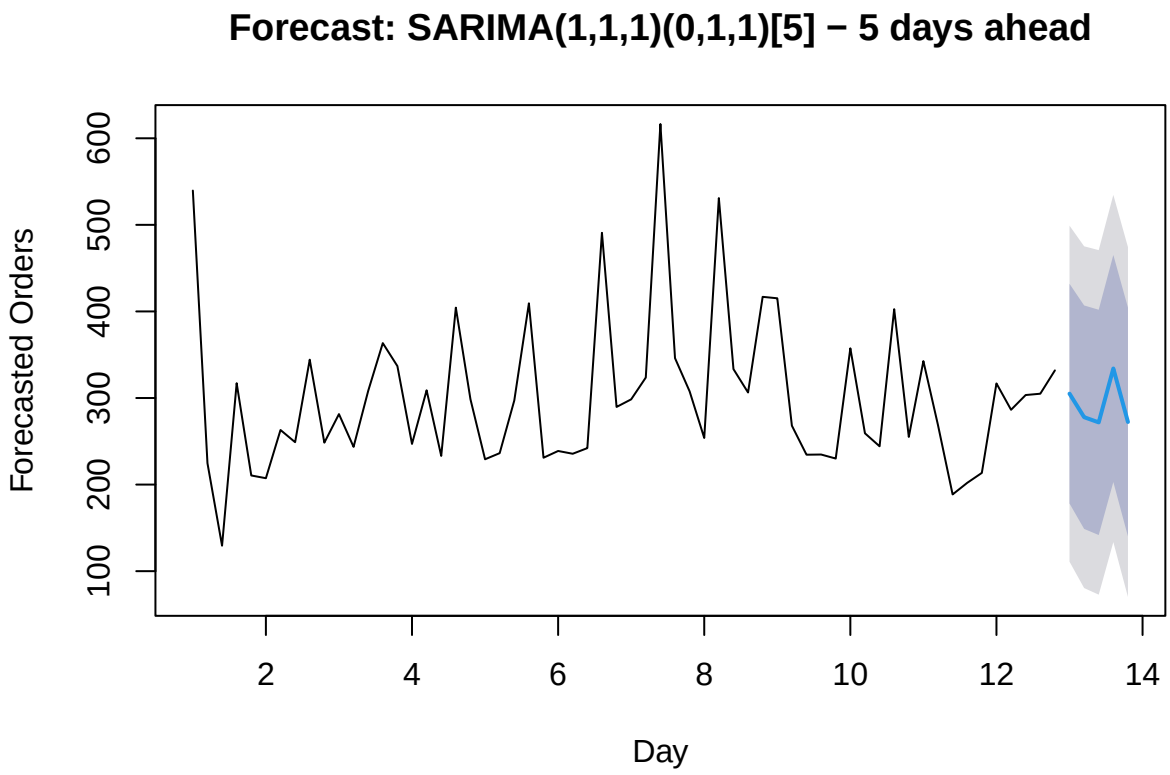
```
##
##  Box-Ljung test
##
## data:  residuals(fit2)
## X-squared = 9.0738, df = 7, p-value = 0.2474
```

```r
qqnorm(residuals(fit2)); qqline(residuals(fit2), col = "red")
```



#8. Forecasting with Model 2 (SARIMA(1,1,1)(0,1,1)[5]) #Interpretation: This model 2 maintains the weekly cycle in the original data with period = 5. There were no big growth or decline. And this indicates that there would be stable seasonality and trend behavior. In short term forecasts, the prediction intervals are relatively narrow. It indicates the high confidence in the short-term forecast. The model projects the same seasonal up and down pattern. Also, in the medium-term forecasts, for example, 1 month to 5 month, the seasonal cycle is preserved. Uncertainty bands widen moderately for further ahead. At the long-term forecast, for instance, 1 year, the forecast still preserved the seasonal pattern but with much wider confidence intervals. I think this shows the realistic modeling. There were no strong unrealistic drift so the model 2 would be the most suitable SARIMA model to forecast. As a result, SARIMA(1,1,1)(0,1,1)[5] makes a stable and seasonally appropriate forecasting. The model is consistent with previous data and contains the reasonable uncertainty bands. Therefore, the model 2 is the most suitable choice for forecasting.

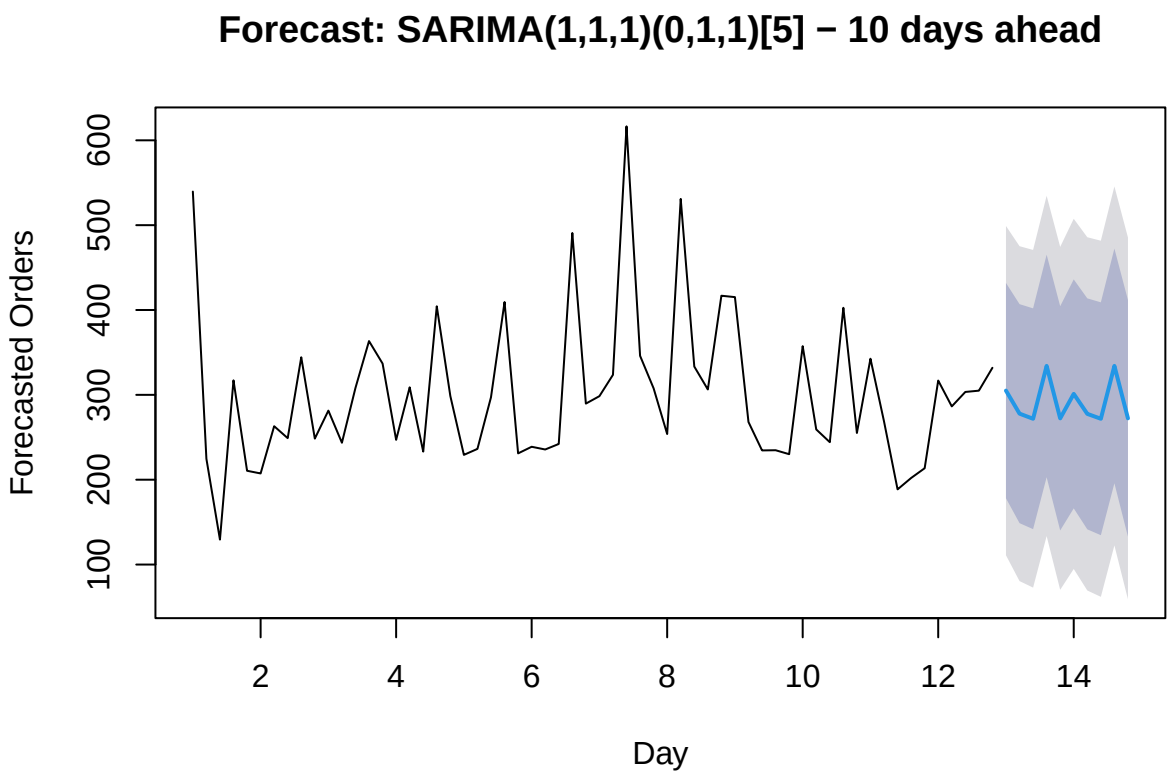
```r
#1. Forecast for the next 5 business days. (Short-term)
forecast_result_fit2 <- forecast(fit2, h = 5, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 5 days ahead", xlab = "Day", yla
```




```r
print(forecast_result_fit2)
```

```
##       Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 13.00       305.0187 178.1410 431.8963 110.97607 499.0613
## 13.20       277.8528 148.8138 406.8917  80.50472 475.2008
## 13.40       271.8225 141.7189 401.9262  72.84621 470.7989
## 13.60       334.0946 202.9906 465.1986 133.58834 534.6008
## 13.80       272.3029 140.1899 404.4159  70.25350 474.3523
```

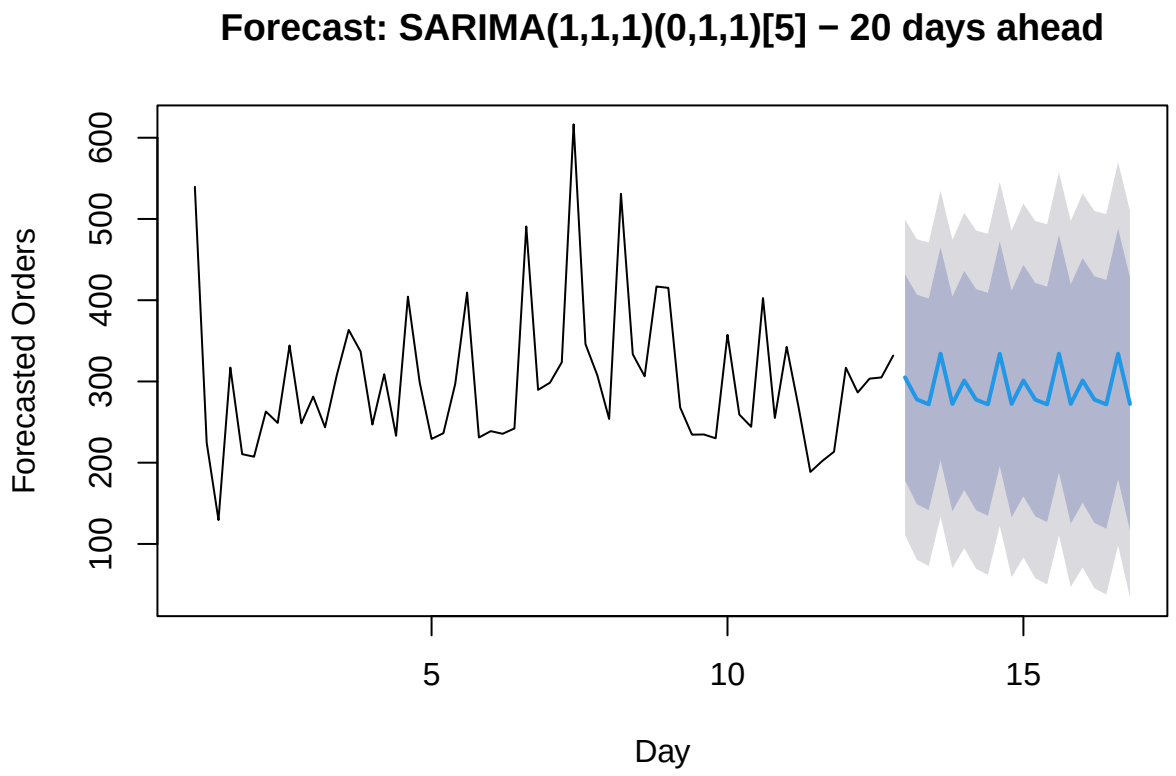
```r
#2. Forecast for the next 10 days.
forecast_result_fit2 <- forecast(fit2, h = 10, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 10 days ahead", xlab = "Day", yl
```




```
print(forecast_result_fit2)
```

```
##       Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 13.00       305.0187 178.1410 431.8963 110.97607 499.0613
## 13.20       277.8528 148.8138 406.8917  80.50472 475.2008
## 13.40       271.8225 141.7189 401.9262  72.84621 470.7989
## 13.60       334.0946 202.9906 465.1986 133.58834 534.6008
## 13.80       272.3029 140.1899 404.4159  70.25350 474.3523
## 14.00       301.1508 166.2323 436.0692  94.81078 507.4907
## 14.20       277.6110 141.5092 413.7128  69.46122 485.7607
## 14.40       271.8167 134.6127 409.0207  61.98124 481.6522
## 14.60       334.1041 195.8094 472.3988 122.60067 545.6075
## 14.80       272.3134 132.9118 411.7150  59.11700 485.5098
```

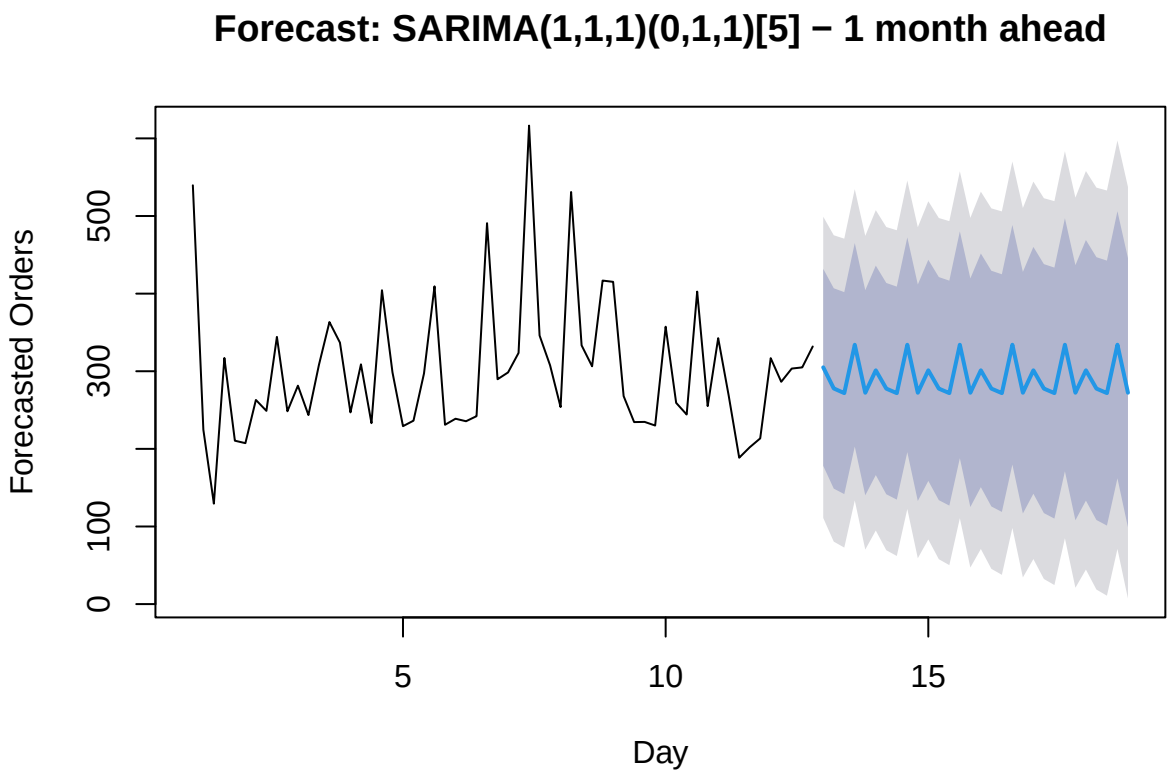
```
#3. Forecast for the next 20 days.
forecast_result_fit2 <- forecast(fit2, h = 20, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 20 days ahead", xlab = "Day", yla
```




```
print(forecast_result_fit2)
```

```
##       Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 13.00       305.0187 178.1410 431.8963 110.97607 499.0613
## 13.20       277.8528 148.8138 406.8917  80.50472 475.2008
## 13.40       271.8225 141.7189 401.9262  72.84621 470.7989
## 13.60       334.0946 202.9906 465.1986 133.58834 534.6008
## 13.80       272.3029 140.1899 404.4159  70.25350 474.3523
## 14.00       301.1508 166.2323 436.0692  94.81078 507.4907
## 14.20       277.6110 141.5092 413.7128  69.46122 485.7607
## 14.40       271.8167 134.6127 409.0207  61.98124 481.6522
## 14.60       334.1041 195.8094 472.3988 122.60067 545.6075
## 14.80       272.3134 132.9118 411.7150  59.11700 485.5098
## 15.00       301.1613 158.7220 443.6007  83.31910 519.0035
## 15.20       277.6216 133.9150 421.3281  57.84142 497.4017
## 15.40       271.8273 126.9379 416.7166  50.23816 493.4164
## 15.60       334.1147 188.0548 480.1746 110.73531 557.4940
## 15.80       272.3240 125.0733 419.5747  47.12343 497.5245
## 16.00       301.1719 150.6862 451.6576  71.02384 531.3199
## 16.20       277.6321 125.8085 429.4558  45.43793 509.8263
## 16.40       271.8378 118.7631 424.9126  37.73018 505.9455
## 16.60       334.1252 179.8120 488.4385  98.12349 570.1270
## 16.80       272.3345 116.7591 427.9100  34.40238 510.2667
```

```r
#4. Forecast for the next 30 days. (1 month)
forecast_result_fit2 <- forecast(fit2, h = 30, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 1 month ahead", xlab = "Day", yla
```

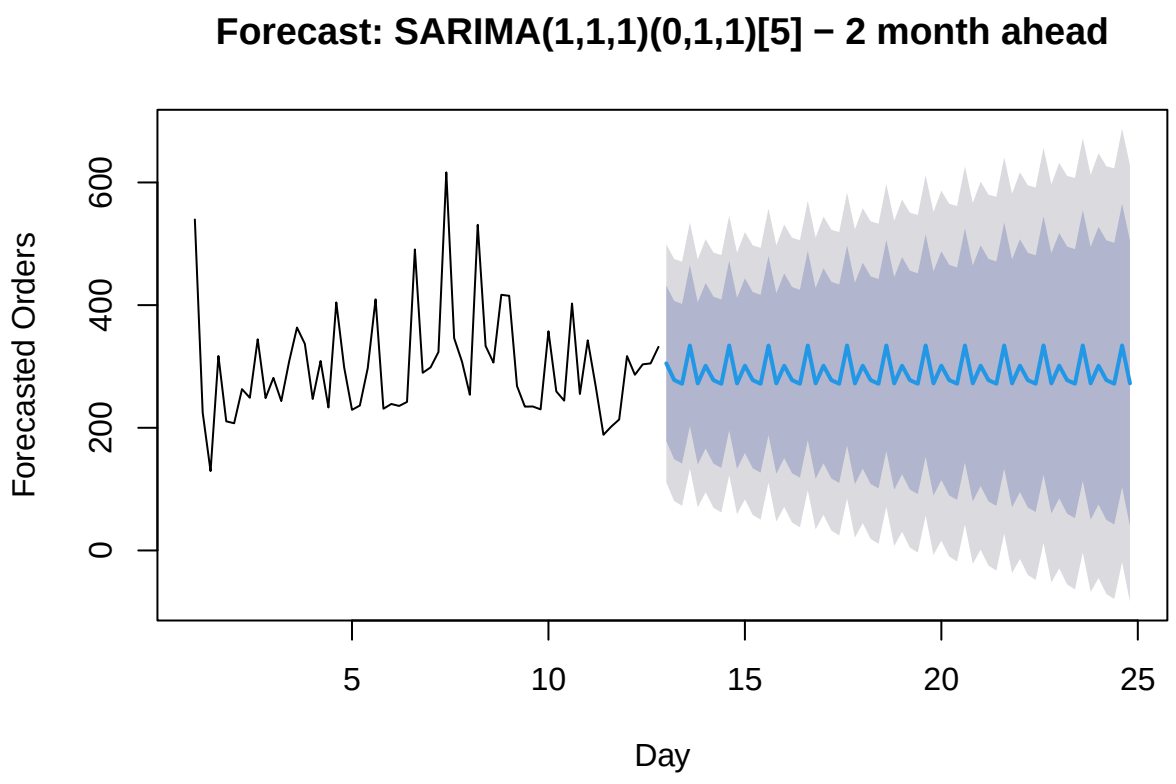



```r
print(forecast_result_fit2)
```

```
##       Point Forecast     Lo 80    Hi 80      Lo 95    Hi 95
## 13.00       305.0187 178.14104 431.8963 110.976071 499.0613
## 13.20       277.8528 148.81382 406.8917  80.504723 475.2008
## 13.40       271.8225 141.71891 401.9262  72.846209 470.7989
## 13.60       334.0946 202.99060 465.1986 133.588344 534.6008
## 13.80       272.3029 140.18989 404.4159  70.253499 474.3523
## 14.00       301.1508 166.23229 436.0692  94.810775 507.4907
## 14.20       277.6110 141.50917 413.7128  69.461225 485.7607
## 14.40       271.8167 134.61266 409.0207  61.981236 481.6522
## 14.60       334.1041 195.80944 472.3988 122.600666 545.6075
## 14.80       272.3134 132.91177 411.7150  59.117004 485.5098
## 15.00       301.1613 158.72195 443.6007  83.319105 519.0035
## 15.20       277.6216 133.91505 421.3281  57.841419 497.4017
## 15.40       271.8273 126.93794 416.7166  50.238162 493.4164
## 15.60       334.1147 188.05476 480.1746 110.735310 557.4940
## 15.80       272.3240 125.07325 419.5747  47.123433 497.5245
## 16.00       301.1719 150.68617 451.6576  71.023840 531.3199
## 16.20       277.6321 125.80850 429.4558  45.437928 509.8263
## 16.40       271.8378 118.76307 424.9126  37.730184 505.9455
```

```
## 16.60       334.1252 179.81199 488.4385  98.123491 570.1270
## 16.80       272.3345 116.75906 427.9100  34.402382 510.2667
## 17.00       301.1825 142.20470 460.1602  58.046961 544.3180
## 17.20       277.6427 117.26732 438.0181  32.369718 522.9157
## 17.40       271.8484 110.16400 433.5328  24.573445 519.1234
## 17.60       334.1358 171.15527 497.1164  84.878584 583.3930
## 17.80       272.3451 108.04149 436.6487  21.064404 523.6258
## 18.00       301.1930 133.34519 469.0409  44.491904 557.8942
## 18.20       277.6533 108.35735 446.9492  18.737501 536.5691
## 18.40       271.8590 101.20492 442.5130  10.866119 532.8519
## 18.60       334.1464 162.14717 506.1456  71.096281 597.1965
## 18.80       272.3557  98.98144 445.7299   7.202656 537.5087
```

```r
#5. Forecast for the next 60 days. (2 month)
forecast_result_fit2 <- forecast(fit2, h = 60, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 2 month ahead", xlab = "Day", yla
```



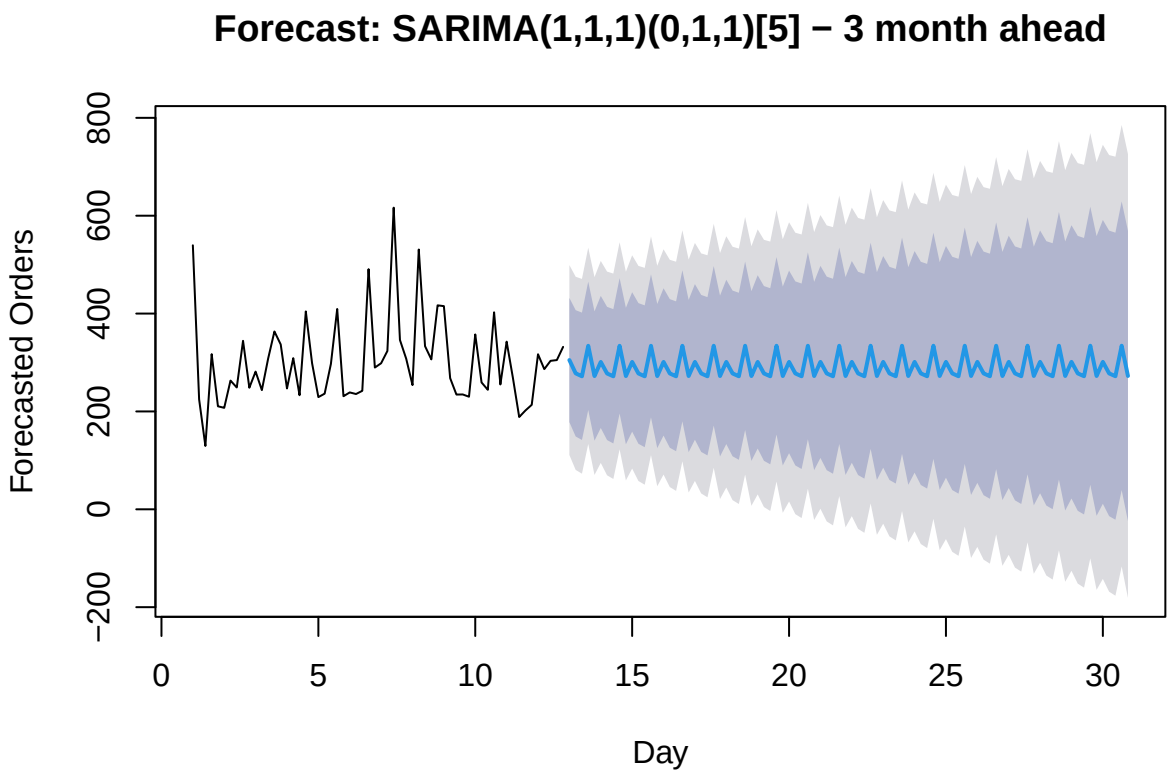

```r
print(forecast_result_fit2)
```

```
##       Point Forecast     Lo 80    Hi 80      Lo 95    Hi 95
## 13.00       305.0187 178.14104 431.8963 110.976071 499.0613
## 13.20       277.8528 148.81382 406.8917  80.504723 475.2008
## 13.40       271.8225 141.71891 401.9262  72.846209 470.7989
## 13.60       334.0946 202.99060 465.1986 133.588344 534.6008
## 13.80       272.3029 140.18989 404.4159  70.253499 474.3523
```

```
## 14.00       301.1508 166.23229 436.0692  94.810775 507.4907
## 14.20       277.6110 141.50917 413.7128  69.461225 485.7607
## 14.40       271.8167 134.61266 409.0207  61.981236 481.6522
## 14.60       334.1041 195.80944 472.3988 122.600666 545.6075
## 14.80       272.3134 132.91177 411.7150  59.117004 485.5098
## 15.00       301.1613 158.72195 443.6007  83.319105 519.0035
## 15.20       277.6216 133.91505 421.3281  57.841419 497.4017
## 15.40       271.8273 126.93794 416.7166  50.238162 493.4164
## 15.60       334.1147 188.05476 480.1746 110.735310 557.4940
## 15.80       272.3240 125.07325 419.5747  47.123433 497.5245
## 16.00       301.1719 150.68617 451.6576  71.023840 531.3199
## 16.20       277.6321 125.80850 429.4558  45.437928 509.8263
## 16.40       271.8378 118.76307 424.9126  37.730184 505.9455
## 16.60       334.1252 179.81199 488.4385  98.123491 570.1270
## 16.80       272.3345 116.75906 427.9100  34.402382 510.2667
## 17.00       301.1825 142.20470 460.1602  58.046961 544.3180
## 17.20       277.6427 117.26732 438.0181  32.369718 522.9157
## 17.40       271.8484 110.16400 433.5328  24.573445 519.1234
## 17.60       334.1358 171.15527 497.1164  84.878584 583.3930
## 17.80       272.3451 108.04149 436.6487  21.064404 523.6258
## 18.00       301.1930 133.34519 469.0409  44.491904 557.8942
## 18.20       277.6533 108.35735 446.9492  18.737501 536.5691
## 18.40       271.8590 101.20492 442.5130  10.866119 532.8519
## 18.60       334.1464 162.14717 506.1456  71.096281 597.1965
## 18.80       272.3557  98.98144 445.7299   7.202656 537.5087
## 19.00       301.2036 124.16444 478.2428  30.445558 571.9617
## 19.20       277.6639  99.13387 456.1938   4.625808 550.7019
## 19.40       271.8696  91.93967 451.7995  -3.309465 547.0486
## 19.60       334.1570 152.84010 515.4738  56.856758 611.4572
## 19.80       272.3663  89.62991 455.1026  -7.104876 551.8374
## 20.00       301.2142 114.70994 487.7184  15.980551 586.4478
## 20.20       277.6744  89.64306 465.7058  -9.894729 565.2436
## 20.40       271.8801  82.41320 461.3471 -17.884541 561.6448
## 20.60       334.1675 143.27785 525.0572  42.226961 626.1081
## 20.80       272.3768  80.02945 464.7242 -21.793108 566.5468
## 21.00       301.2248 105.02130 497.4282   1.157465 601.2921
## 21.20       277.6850  79.92345 475.4465 -24.765189 580.1352
## 21.40       271.8907  72.66302 471.1184 -32.801742 576.5832
## 21.60       334.1781 133.49693 534.8593  27.262735 641.0935
## 21.80       272.3874  70.21556 474.5593 -36.807749 581.5826
## 22.00       301.2353  95.13158 507.3391 -13.973150 616.4438
## 22.20       277.6956  70.00719 485.3839 -39.936392 595.3275
## 22.40       271.9013  62.72046 481.0821 -48.013182 591.8157
## 22.60       334.1887 123.52783 544.8495  12.010709 656.3667
## 22.80       272.3980  60.21789 484.5781 -52.103463 596.8994
## 23.00       301.2459  85.06841 517.4234 -29.369045 631.8609
## 23.20       277.7061  59.92118 495.4911 -55.367218 610.7795
## 23.40       271.9119  52.61169 491.2120 -63.478798 607.3025
## 23.60       334.1993 113.39606 555.0024  -3.490095 671.8886
## 23.80       272.4086  50.06125 494.7559 -67.642297 612.4594
## 24.00       301.2565  74.85493 527.6580 -44.994811 647.5078
## 24.20       277.7167  49.68795 505.7455 -71.023182 626.4566
## 24.40       271.9224  42.35871 501.4861 -79.164980 623.0098
## 24.60       334.2098 103.12303 565.2966 -19.206924 687.6266
```

```
## 24.80       272.4191  39.76649 505.0718 -83.392378 628.2306
```

```
#6. Forecast for the next 90 days. (3 month)
forecast_result_fit2 <- forecast(fit2, h = 90, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 3 month ahead", xlab = "Day", yla
```



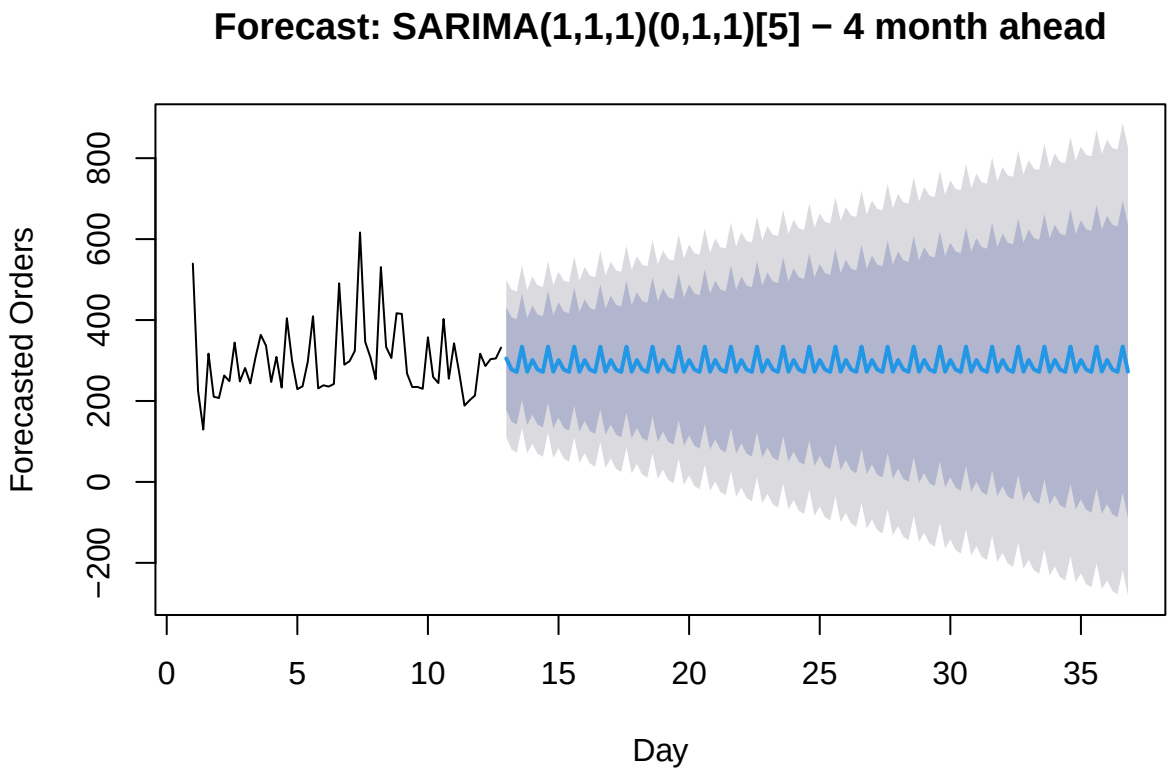

```
print(forecast_result_fit2)
```

```
##       Point Forecast       Lo 80    Hi 80       Lo 95    Hi 95
## 13.00       305.0187 178.1410388 431.8963  110.976071 499.0613
## 13.20       277.8528 148.8138204 406.8917   80.504723 475.2008
## 13.40       271.8225 141.7189107 401.9262   72.846209 470.7989
## 13.60       334.0946 202.9906030 465.1986  133.588344 534.6008
## 13.80       272.3029 140.1898945 404.4159   70.253499 474.3523
## 14.00       301.1508 166.2322929 436.0692   94.810775 507.4907
## 14.20       277.6110 141.5091728 413.7128   69.461225 485.7607
## 14.40       271.8167 134.6126627 409.0207   61.981236 481.6522
## 14.60       334.1041 195.8094363 472.3988  122.600666 545.6075
## 14.80       272.3134 132.9117676 411.7150   59.117004 485.5098
## 15.00       301.1613 158.7219516 443.6007   83.319105 519.0035
## 15.20       277.6216 133.9150498 421.3281   57.841419 497.4017
## 15.40       271.8273 126.9379392 416.7166   50.238162 493.4164
## 15.60       334.1147 188.0547568 480.1746  110.735310 557.4940
## 15.80       272.3240 125.0732530 419.5747   47.123433 497.5245
## 16.00       301.1719 150.6861695 451.6576   71.023840 531.3199
```

```
## 16.20       277.6321 125.8085029 429.4558   45.437928 509.8263
## 16.40       271.8378 118.7630713 424.9126   37.730184 505.9455
## 16.60       334.1252 179.8119910 488.4385   98.123491 570.1270
## 16.80       272.3345 116.7590646 427.9100   34.402382 510.2667
## 17.00       301.1825 142.2047043 460.1602   58.046961 544.3180
## 17.20       277.6427 117.2673192 438.0181   32.369718 522.9157
## 17.40       271.8484 110.1640019 433.5328   24.573445 519.1234
## 17.60       334.1358 171.1552721 497.1164   84.878584 583.3930
## 17.80       272.3451 108.0414892 436.6487   21.064404 523.6258
## 18.00       301.1930 133.3451885 469.0409   44.491904 557.8942
## 18.20       277.6533 108.3573512 446.9492   18.737501 536.5691
## 18.40       271.8590 101.2049230 442.5130   10.866119 532.8519
## 18.60       334.1464 162.1471677 506.1456   71.096281 597.1965
## 18.80       272.3557  98.9814391 445.7299    7.202656 537.5087
## 19.00       301.2036 124.1644366 478.2428   30.445558 571.9617
## 19.20       277.6639  99.1338709 456.1938    4.625808 550.7019
## 19.40       271.8696  91.9396667 451.7995   -3.309465 547.0486
## 19.60       334.1570 152.8401039 515.4738   56.856758 611.4572
## 19.80       272.3663  89.6299060 455.1026   -7.104876 551.8374
## 20.00       301.2142 114.7099362 487.7184   15.980551 586.4478
## 20.20       277.6744  89.6430616 465.7058   -9.894729 565.2436
## 20.40       271.8801  82.4131967 461.3471  -17.884541 561.6448
## 20.60       334.1675 143.2778536 525.0572   42.226961 626.1081
## 20.80       272.3768  80.0294473 464.7242  -21.793108 566.5468
## 21.00       301.2248 105.0213011 497.4282    1.157465 601.2921
## 21.20       277.6850  79.9234506 475.4465  -24.765189 580.1352
## 21.40       271.8907  72.6630224 471.1184  -32.801742 576.5832
## 21.60       334.1781 133.4969319 534.8593   27.262735 641.0935
## 21.80       272.3874  70.2155607 474.5593  -36.807749 581.5826
## 22.00       301.2353  95.1315835 507.3391  -13.973150 616.4438
## 22.20       277.6956  70.0071935 485.3839  -39.936392 595.3275
## 22.40       271.9013  62.7204567 481.0821  -48.013182 591.8157
## 22.60       334.1887 123.5278281 544.8495   12.010709 656.3667
## 22.80       272.3980  60.2178907 484.5781  -52.103463 596.8994
## 23.00       301.2459  85.0684086 517.4234  -29.369045 631.8609
## 23.20       277.7061  59.9211784 495.4911  -55.367218 610.7795
## 23.40       271.9119  52.6116935 491.2120  -63.478798 607.3025
## 23.60       334.1993 113.3960565 555.0024   -3.490095 671.8886
## 23.80       272.4086  50.0612533 494.7559  -67.642297 612.4594
## 24.00       301.2565  74.8549291 527.6580  -44.994811 647.5078
## 24.20       277.7167  49.6879537 505.7455  -71.023182 626.4566
## 24.40       271.9224  42.3587102 501.4861  -79.164980 623.0098
## 24.60       334.2098 103.1230345 565.2966  -19.206924 687.6266
## 24.80       272.4191  39.7664886 505.0718  -83.392378 628.2306
## 25.00       301.2671  64.5106164 538.0235  -60.820669 663.3548
## 25.20       277.7273  39.3264947 516.1281  -86.875263 642.3298
## 25.40       271.9330  31.9800121 511.8860  -95.043426 638.9094
## 25.60       334.2204  92.7268060 575.7140  -35.112180 703.5530
## 25.80       272.4297  29.3511638 515.5082  -99.326840 644.1862
## 26.00       301.2776  54.0519095 548.5033  -76.821478 679.3767
## 26.20       277.7379  28.8528332 526.6229 -102.898943 658.3747
## 26.40       271.9436  21.4912436 522.3959 -111.090210 654.9774
## 26.60       334.2310  82.2226342 586.2393  -51.182522 719.6445
## 26.80       272.4403  18.8301470 526.0504 -115.422943 660.3035
```

```
## 27.00       301.2882  43.4927449 559.0836  -92.975924 695.5523
## 27.20       277.7484  18.2805698 537.2163 -119.073422 674.5703
## 27.40       271.9541  10.9056853 533.0026 -127.285021 671.1933
## 27.60       334.2415  71.6234843 596.8596  -67.398120 735.8812
## 27.80       272.4508   8.2160756 536.6856 -131.661362 676.5631
## 28.00       301.2988  32.8449881 569.7526 -109.265860 711.8634
## 28.20       277.7590   7.6212928 547.8967 -135.380976 690.8990
## 28.40       271.9647   0.2346598 543.6948 -143.610544 687.5400
## 28.60       334.2521  60.9404169 607.5638  -83.742058 752.2463
## 28.80       272.4614  -2.4802629 547.4031 -148.025597 692.9484
## 29.00       301.3093  22.1187853 580.4999 -125.675769 728.2945
## 29.20       277.7696  -3.1150822 558.6542 -151.806442 707.3456
## 29.40       271.9753 -10.5121377 554.4627 -160.051949 704.0025
## 29.60       334.2627  50.1829085 618.3425 -100.199845 768.7252
## 29.80       272.4720 -13.2496203 558.1936 -164.501505 709.4455
## 30.00       301.3199  11.3228492 591.3170 -142.192325 744.8322
## 30.20       277.7802 -13.9200337 569.4803 -168.336786 723.8971
## 30.40       271.9859 -21.3263706 565.2981 -176.596488 720.5682
## 30.60       334.2733  39.3591132 629.1874 -116.759008 785.3055
## 30.80       272.4826 -24.0840340 569.0492 -181.076908 726.0420
```

```r
#7. Forecast for the next 120 days. (4 month)
forecast_result_fit2 <- forecast(fit2, h = 120, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 4 month ahead", xlab = "Day", yla
```



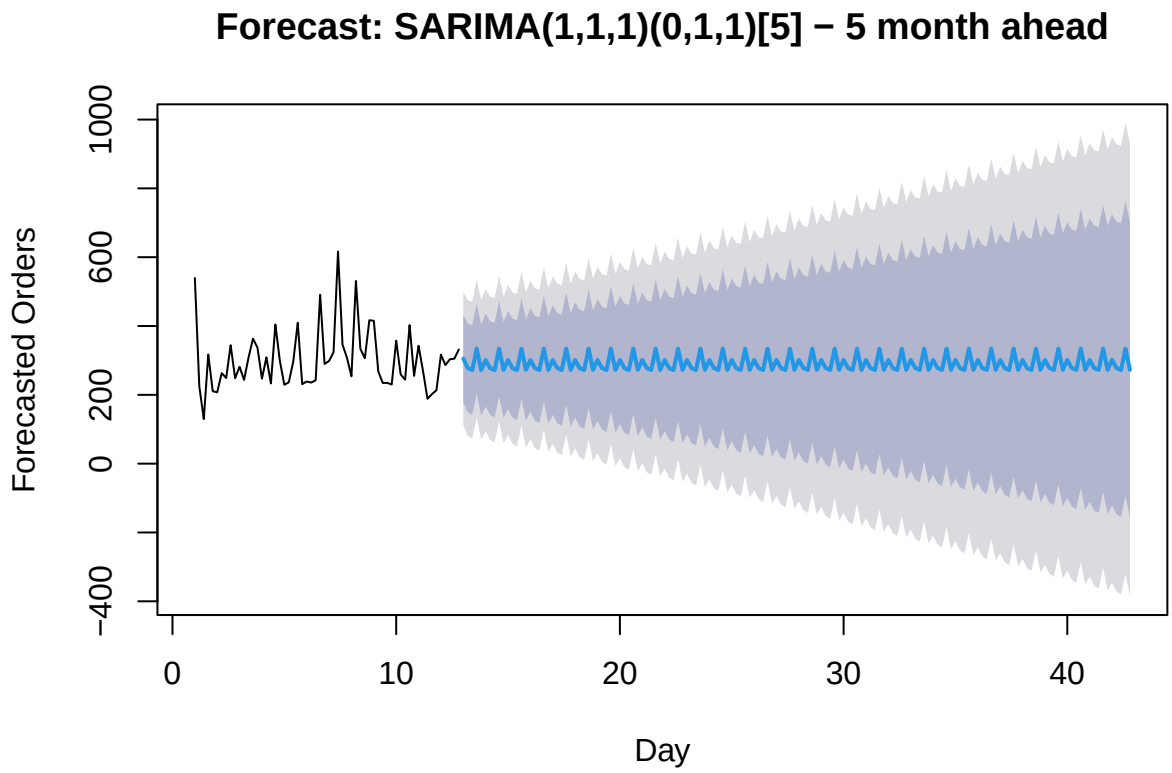
```r
print(forecast_result_fit2)
```

```
##       Point Forecast       Lo 80    Hi 80       Lo 95    Hi 95
## 13.00       305.0187 178.1410388 431.8963  110.976071 499.0613
## 13.20       277.8528 148.8138204 406.8917   80.504723 475.2008
## 13.40       271.8225 141.7189107 401.9262   72.846209 470.7989
## 13.60       334.0946 202.9906030 465.1986  133.588344 534.6008
## 13.80       272.3029 140.1898945 404.4159   70.253499 474.3523
## 14.00       301.1508 166.2322929 436.0692   94.810775 507.4907
## 14.20       277.6110 141.5091728 413.7128   69.461225 485.7607
## 14.40       271.8167 134.6126627 409.0207   61.981236 481.6522
## 14.60       334.1041 195.8094363 472.3988  122.600666 545.6075
## 14.80       272.3134 132.9117676 411.7150   59.117004 485.5098
## 15.00       301.1613 158.7219516 443.6007   83.319105 519.0035
## 15.20       277.6216 133.9150498 421.3281   57.841419 497.4017
## 15.40       271.8273 126.9379392 416.7166   50.238162 493.4164
## 15.60       334.1147 188.0547568 480.1746  110.735310 557.4940
## 15.80       272.3240 125.0732530 419.5747   47.123433 497.5245
## 16.00       301.1719 150.6861695 451.6576   71.023840 531.3199
## 16.20       277.6321 125.8085029 429.4558   45.437928 509.8263
## 16.40       271.8378 118.7630713 424.9126   37.730184 505.9455
## 16.60       334.1252 179.8119910 488.4385   98.123491 570.1270
## 16.80       272.3345 116.7590646 427.9100   34.402382 510.2667
## 17.00       301.1825 142.2047043 460.1602   58.046961 544.3180
## 17.20       277.6427 117.2673192 438.0181   32.369718 522.9157
## 17.40       271.8484 110.1640019 433.5328   24.573445 519.1234
## 17.60       334.1358 171.1552721 497.1164   84.878584 583.3930
## 17.80       272.3451 108.0414892 436.6487   21.064404 523.6258
## 18.00       301.1930 133.3451885 469.0409   44.491904 557.8942
## 18.20       277.6533 108.3573512 446.9492   18.737501 536.5691
## 18.40       271.8590 101.2049230 442.5130   10.866119 532.8519
## 18.60       334.1464 162.1471677 506.1456   71.096281 597.1965
## 18.80       272.3557  98.9814391 445.7299    7.202656 537.5087
## 19.00       301.2036 124.1644366 478.2428   30.445558 571.9617
## 19.20       277.6639  99.1338709 456.1938    4.625808 550.7019
## 19.40       271.8696  91.9396667 451.7995   -3.309465 547.0486
## 19.60       334.1570 152.8401039 515.4738   56.856758 611.4572
## 19.80       272.3663  89.6299060 455.1026   -7.104876 551.8374
## 20.00       301.2142 114.7099362 487.7184   15.980551 586.4478
## 20.20       277.6744  89.6430616 465.7058   -9.894729 565.2436
## 20.40       271.8801  82.4131967 461.3471  -17.884541 561.6448
## 20.60       334.1675 143.2778536 525.0572   42.226961 626.1081
## 20.80       272.3768  80.0294473 464.7242  -21.793108 566.5468
## 21.00       301.2248 105.0213011 497.4282    1.157465 601.2921
## 21.20       277.6850  79.9234506 475.4465  -24.765189 580.1352
## 21.40       271.8907  72.6630224 471.1184  -32.801742 576.5832
## 21.60       334.1781 133.4969319 534.8593   27.262735 641.0935
## 21.80       272.3874  70.2155607 474.5593  -36.807749 581.5826
## 22.00       301.2353  95.1315835 507.3391  -13.973150 616.4438
## 22.20       277.6956  70.0071935 485.3839  -39.936392 595.3275
## 22.40       271.9013  62.7204567 481.0821  -48.013182 591.8157
## 22.60       334.1887 123.5278281 544.8495   12.010709 656.3667
## 22.80       272.3980  60.2178907 484.5781  -52.103463 596.8994
```

```
## 23.00       301.2459  85.0684086 517.4234  -29.369045 631.8609
## 23.20       277.7061  59.9211784 495.4911  -55.367218 610.7795
## 23.40       271.9119  52.6116935 491.2120  -63.478798 607.3025
## 23.60       334.1993 113.3960565 555.0024   -3.490095 671.8886
## 23.80       272.4086  50.0612533 494.7559  -67.642297 612.4594
## 24.00       301.2565  74.8549291 527.6580  -44.994811 647.5078
## 24.20       277.7167  49.6879537 505.7455  -71.023182 626.4566
## 24.40       271.9224  42.3587102 501.4861  -79.164980 623.0098
## 24.60       334.2098 103.1230345 565.2966  -19.206924 687.6266
## 24.80       272.4191  39.7664886 505.0718  -83.392378 628.2306
## 25.00       301.2671  64.5106164 538.0235  -60.820669 663.3548
## 25.20       277.7273  39.3264947 516.1281  -86.875263 642.3298
## 25.40       271.9330  31.9800121 511.8860  -95.043426 638.9094
## 25.60       334.2204  92.7268060 575.7140  -35.112180 703.5530
## 25.80       272.4297  29.3511638 515.5082  -99.326840 644.1862
## 26.00       301.2776  54.0519095 548.5033  -76.821478 679.3767
## 26.20       277.7379  28.8528332 526.6229 -102.898943 658.3747
## 26.40       271.9436  21.4912436 522.3959 -111.090210 654.9774
## 26.60       334.2310  82.2226342 586.2393  -51.182522 719.6445
## 26.80       272.4403  18.8301470 526.0504 -115.422943 660.3035
## 27.00       301.2882  43.4927449 559.0836  -92.975924 695.5523
## 27.20       277.7484  18.2805698 537.2163 -119.073422 674.5703
## 27.40       271.9541  10.9056853 533.0026 -127.285021 671.1933
## 27.60       334.2415  71.6234843 596.8596  -67.398120 735.8812
## 27.80       272.4508   8.2160756 536.6856 -131.661362 676.5631
## 28.00       301.2988  32.8449881 569.7526 -109.265860 711.8634
## 28.20       277.7590   7.6212928 547.8967 -135.380976 690.8990
## 28.40       271.9647   0.2346598 543.6948 -143.610544 687.5400
## 28.60       334.2521  60.9404169 607.5638  -83.742058 752.2463
## 28.80       272.4614  -2.4802629 547.4031 -148.025597 692.9484
## 29.00       301.3093  22.1187853 580.4999 -125.675769 728.2945
## 29.20       277.7696  -3.1150822 558.6542 -151.806442 707.3456
## 29.40       271.9753 -10.5121377 554.4627 -160.051949 704.0025
## 29.60       334.2627  50.1829085 618.3425 -100.199845 768.7252
## 29.80       272.4720 -13.2496203 558.1936 -164.501505 709.4455
## 30.00       301.3199  11.3228492 591.3170 -142.192325 744.8322
## 30.20       277.7802 -13.9200337 569.4803 -168.336786 723.8971
## 30.40       271.9859 -21.3263706 565.2981 -176.596488 720.5682
## 30.60       334.2733  39.3591132 629.1874 -116.759008 785.3055
## 30.80       272.4826 -24.0840340 569.0492 -181.076908 726.0420
## 31.00       301.3305   0.4646939 602.1963 -158.804038 761.4650
## 31.20       277.7907 -24.7862082 580.3677 -184.960763 740.5422
## 31.40       271.9964 -32.2008398 576.1937 -193.233151 737.2260
## 31.60       334.2838  28.4760761 640.0916 -133.408774 801.9765
## 31.80       272.4931 -34.9766204 579.9629 -197.741278 742.7276
## 32.00       301.3411 -10.4491741 613.1313 -175.500955 778.1831
## 32.20       277.8013 -35.7072337 591.3098 -201.668627 757.2712
## 32.40       272.0070 -43.1293037 587.1433 -209.952391 753.9664
## 32.60       334.2944  17.5399095 651.0489 -150.139795 818.7286
## 32.80       272.5037 -45.9214038 590.9288 -214.485477 759.4929
## 33.00       301.3516 -21.4130978 624.1164 -192.274427 794.9777
## 33.20       277.8119 -46.6775665 602.3013 -218.451901 774.0757
## 33.40       272.0176 -54.1063290 598.1415 -226.745900 770.7811
## 33.60       334.3050   6.5559367 662.0540 -166.943929 835.5539
```

```
## 33.80       272.5143 -56.9131767 601.9417 -231.301540 776.3301
## 34.00       301.3622 -32.4221399 635.1466 -209.116901 811.8413
## 34.20       277.8224 -57.6923656 613.3373 -235.303179 790.9481
## 34.40       272.0282 -65.1271680 609.1835 -243.606415 787.6627
## 34.60       334.3156  -4.4711880 673.1023 -183.814058 852.4452
## 34.80       272.5249 -67.9473839 612.9971 -248.182501 793.2322
## 35.00       301.3728 -43.4719751 646.2175 -226.021762 828.7673
## 35.20       277.8330 -68.7473874 624.4134 -252.215973 807.8820
## 35.40       272.0387 -76.1876569 620.2651 -260.527570 804.6050
## 35.60       334.3261 -15.5373804 684.1896 -200.743935 869.3962
## 35.80       272.5354 -79.0200259 624.0909 -265.122242 810.1931
## 36.00       301.3834 -54.5588008 657.3255 -242.983196 845.7499
## 36.20       277.8436 -79.8388987 635.5261 -269.184573 824.8718
## 36.40       272.0493 -87.2841308 631.3827 -277.503760 821.6024
## 36.60       334.3367 -26.6390442 695.3125 -217.728062 886.4015
## 36.80       272.5460 -90.1275790 635.2196 -282.115376 827.2074
```

```
#8. Forecast for the next 150 days. (5 month)
forecast_result_fit2 <- forecast(fit2, h = 150, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 5 month ahead", xlab = "Day", yla
```




```
print(forecast_result_fit2)
```

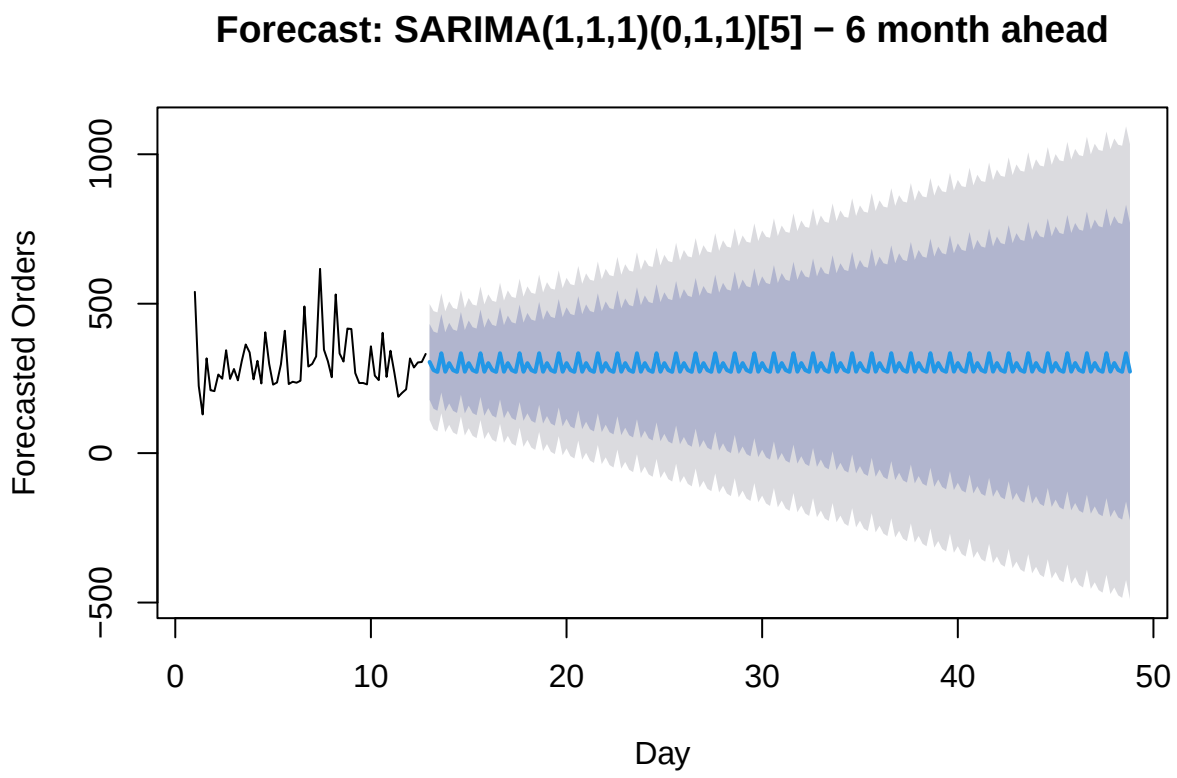
```
##       Point Forecast        Lo 80    Hi 80       Lo 95    Hi 95
## 13.00       305.0187  178.1410388 431.8963  110.976071 499.0613
```

```
## 13.20       277.8528  148.8138204 406.8917   80.504723 475.2008
## 13.40       271.8225  141.7189107 401.9262   72.846209 470.7989
## 13.60       334.0946  202.9906030 465.1986  133.588344 534.6008
## 13.80       272.3029  140.1898945 404.4159   70.253499 474.3523
## 14.00       301.1508  166.2322929 436.0692   94.810775 507.4907
## 14.20       277.6110  141.5091728 413.7128   69.461225 485.7607
## 14.40       271.8167  134.6126627 409.0207   61.981236 481.6522
## 14.60       334.1041  195.8094363 472.3988  122.600666 545.6075
## 14.80       272.3134  132.9117676 411.7150   59.117004 485.5098
## 15.00       301.1613  158.7219516 443.6007   83.319105 519.0035
## 15.20       277.6216  133.9150498 421.3281   57.841419 497.4017
## 15.40       271.8273  126.9379392 416.7166   50.238162 493.4164
## 15.60       334.1147  188.0547568 480.1746  110.735310 557.4940
## 15.80       272.3240  125.0732530 419.5747   47.123433 497.5245
## 16.00       301.1719  150.6861695 451.6576   71.023840 531.3199
## 16.20       277.6321  125.8085029 429.4558   45.437928 509.8263
## 16.40       271.8378  118.7630713 424.9126   37.730184 505.9455
## 16.60       334.1252  179.8119910 488.4385   98.123491 570.1270
## 16.80       272.3345  116.7590646 427.9100   34.402382 510.2667
## 17.00       301.1825  142.2047043 460.1602   58.046961 544.3180
## 17.20       277.6427  117.2673192 438.0181   32.369718 522.9157
## 17.40       271.8484  110.1640019 433.5328   24.573445 519.1234
## 17.60       334.1358  171.1552721 497.1164   84.878584 583.3930
## 17.80       272.3451  108.0414892 436.6487   21.064404 523.6258
## 18.00       301.1930  133.3451885 469.0409   44.491904 557.8942
## 18.20       277.6533  108.3573512 446.9492   18.737501 536.5691
## 18.40       271.8590  101.2049230 442.5130   10.866119 532.8519
## 18.60       334.1464  162.1471677 506.1456   71.096281 597.1965
## 18.80       272.3557   98.9814391 445.7299    7.202656 537.5087
## 19.00       301.2036  124.1644366 478.2428   30.445558 571.9617
## 19.20       277.6639   99.1338709 456.1938    4.625808 550.7019
## 19.40       271.8696   91.9396667 451.7995   -3.309465 547.0486
## 19.60       334.1570  152.8401039 515.4738   56.856758 611.4572
## 19.80       272.3663   89.6299060 455.1026   -7.104876 551.8374
## 20.00       301.2142  114.7099362 487.7184   15.980551 586.4478
## 20.20       277.6744   89.6430616 465.7058   -9.894729 565.2436
## 20.40       271.8801   82.4131967 461.3471  -17.884541 561.6448
## 20.60       334.1675  143.2778536 525.0572   42.226961 626.1081
## 20.80       272.3768   80.0294473 464.7242  -21.793108 566.5468
## 21.00       301.2248  105.0213011 497.4282    1.157465 601.2921
## 21.20       277.6850   79.9234506 475.4465  -24.765189 580.1352
## 21.40       271.8907   72.6630224 471.1184  -32.801742 576.5832
## 21.60       334.1781  133.4969319 534.8593   27.262735 641.0935
## 21.80       272.3874   70.2155607 474.5593  -36.807749 581.5826
## 22.00       301.2353   95.1315835 507.3391  -13.973150 616.4438
## 22.20       277.6956   70.0071935 485.3839  -39.936392 595.3275
## 22.40       271.9013   62.7204567 481.0821  -48.013182 591.8157
## 22.60       334.1887  123.5278281 544.8495   12.010709 656.3667
## 22.80       272.3980   60.2178907 484.5781  -52.103463 596.8994
## 23.00       301.2459   85.0684086 517.4234  -29.369045 631.8609
## 23.20       277.7061   59.9211784 495.4911  -55.367218 610.7795
## 23.40       271.9119   52.6116935 491.2120  -63.478798 607.3025
## 23.60       334.1993  113.3960565 555.0024   -3.490095 671.8886
## 23.80       272.4086   50.0612533 494.7559  -67.642297 612.4594
```

```
## 24.00       301.2565   74.8549291 527.6580  -44.994811 647.5078
## 24.20       277.7167   49.6879537 505.7455  -71.023182 626.4566
## 24.40       271.9224   42.3587102 501.4861  -79.164980 623.0098
## 24.60       334.2098  103.1230345 565.2966  -19.206924 687.6266
## 24.80       272.4191   39.7664886 505.0718  -83.392378 628.2306
## 25.00       301.2671   64.5106164 538.0235  -60.820669 663.3548
## 25.20       277.7273   39.3264947 516.1281  -86.875263 642.3298
## 25.40       271.9330   31.9800121 511.8860  -95.043426 638.9094
## 25.60       334.2204   92.7268060 575.7140  -35.112180 703.5530
## 25.80       272.4297   29.3511638 515.5082  -99.326840 644.1862
## 26.00       301.2776   54.0519095 548.5033  -76.821478 679.3767
## 26.20       277.7379   28.8528332 526.6229 -102.898943 658.3747
## 26.40       271.9436   21.4912436 522.3959 -111.090210 654.9774
## 26.60       334.2310   82.2226342 586.2393  -51.182522 719.6445
## 26.80       272.4403   18.8301470 526.0504 -115.422943 660.3035
## 27.00       301.2882   43.4927449 559.0836  -92.975924 695.5523
## 27.20       277.7484   18.2805698 537.2163 -119.073422 674.5703
## 27.40       271.9541   10.9056853 533.0026 -127.285021 671.1933
## 27.60       334.2415   71.6234843 596.8596  -67.398120 735.8812
## 27.80       272.4508    8.2160756 536.6856 -131.661362 676.5631
## 28.00       301.2988   32.8449881 569.7526 -109.265860 711.8634
## 28.20       277.7590    7.6212928 547.8967 -135.380976 690.8990
## 28.40       271.9647    0.2346598 543.6948 -143.610544 687.5400
## 28.60       334.2521   60.9404169 607.5638  -83.742058 752.2463
## 28.80       272.4614   -2.4802629 547.4031 -148.025597 692.9484
## 29.00       301.3093   22.1187853 580.4999 -125.675769 728.2945
## 29.20       277.7696   -3.1150822 558.6542 -151.806442 707.3456
## 29.40       271.9753  -10.5121377 554.4627 -160.051949 704.0025
## 29.60       334.2627   50.1829085 618.3425 -100.199845 768.7252
## 29.80       272.4720  -13.2496203 558.1936 -164.501505 709.4455
## 30.00       301.3199   11.3228492 591.3170 -142.192325 744.8322
## 30.20       277.7802  -13.9200337 569.4803 -168.336786 723.8971
## 30.40       271.9859  -21.3263706 565.2981 -176.596488 720.5682
## 30.60       334.2733   39.3591132 629.1874 -116.759008 785.3055
## 30.80       272.4826  -24.0840340 569.0492 -181.076908 726.0420
## 31.00       301.3305    0.4646939 602.1963 -158.804038 761.4650
## 31.20       277.7907  -24.7862082 580.3677 -184.960763 740.5422
## 31.40       271.9964  -32.2008398 576.1937 -193.233151 737.2260
## 31.60       334.2838   28.4760761 640.0916 -133.408774 801.9765
## 31.80       272.4931  -34.9766204 579.9629 -197.741278 742.7276
## 32.00       301.3411  -10.4491741 613.1313 -175.500955 778.1831
## 32.20       277.8013  -35.7072337 591.3098 -201.668627 757.2712
## 32.40       272.0070  -43.1293037 587.1433 -209.952391 753.9664
## 32.60       334.2944   17.5399095 651.0489 -150.139795 818.7286
## 32.80       272.5037  -45.9214038 590.9288 -214.485477 759.4929
## 33.00       301.3516  -21.4130978 624.1164 -192.274427 794.9777
## 33.20       277.8119  -46.6775665 602.3013 -218.451901 774.0757
## 33.40       272.0176  -54.1063290 598.1415 -226.745900 770.7811
## 33.60       334.3050    6.5559367 662.0540 -166.943929 835.5539
## 33.80       272.5143  -56.9131767 601.9417 -231.301540 776.3301
## 34.00       301.3622  -32.4221399 635.1466 -209.116901 811.8413
## 34.20       277.8224  -57.6923656 613.3373 -235.303179 790.9481
## 34.40       272.0282  -65.1271680 609.1835 -243.606415 787.6627
## 34.60       334.3156   -4.4711880 673.1023 -183.814058 852.4452
```

```
## 34.80       272.5249  -67.9473839 612.9971 -248.182501 793.2322
## 35.00       301.3728  -43.4719751 646.2175 -226.021762 828.7673
## 35.20       277.8330  -68.7473874 624.4134 -252.215973 807.8820
## 35.40       272.0387  -76.1876569 620.2651 -260.527570 804.6050
## 35.60       334.3261  -15.5373804 684.1896 -200.743935 869.3962
## 35.80       272.5354  -79.0200259 624.0909 -265.122242 810.1931
## 36.00       301.3834  -54.5588008 657.3255 -242.983196 845.7499
## 36.20       277.8436  -79.8388987 635.5261 -269.184573 824.8718
## 36.40       272.0493  -87.2841308 631.3827 -277.503760 821.6024
## 36.60       334.3367  -26.6390442 695.3125 -217.728062 886.4015
## 36.80       272.5460  -90.1275790 635.2196 -282.115376 827.2074
## 37.00       301.3939  -65.6792620 668.4671 -259.996071 862.7839
## 37.20       277.8542  -90.9636044 646.6719 -286.203939 841.9123
## 37.40       272.0599  -98.4133533 642.5331 -294.530034 838.6498
## 37.60       334.3473  -37.7730016 706.4676 -234.761578 903.4561
## 37.80       272.5566 -101.2669285 646.3801 -299.157138 844.2703
## 38.00       301.4045  -76.8303893 679.6394 -277.055846 879.8648
## 38.20       277.8647 -102.1185862 657.8481 -303.269609 858.9991
## 38.40       272.0704 -109.5724567 653.7134 -311.602007 855.7429
## 38.60       334.3578  -48.9364359 717.6521 -251.840174 920.5559
## 38.80       272.5671 -112.4353117 657.5696 -316.243303 861.3776
## 39.00       301.4151  -88.0095458 690.8397 -294.158487 896.9886
## 39.20       277.8753 -113.3012518 669.0519 -320.377617 876.1282
## 39.40       272.0810 -120.7588921 664.9209 -328.715781 872.8778
## 39.60       334.3684  -60.1268423 728.8637 -268.960021 937.6969
## 39.80       272.5777 -123.6302712 668.7857 -333.370113 878.5256
## 40.00       301.4256  -99.2143831 702.0657 -311.300404 914.1517
## 40.20       277.8859 -124.5092908 680.2811 -337.524430 893.2962
## 40.40       272.0916 -131.9703875 676.1536 -345.867880 890.0511
## 40.60       334.3790  -71.3419869 740.1000 -286.117701 954.8757
## 40.80       272.5883 -134.8496142 680.0262 -350.534215 895.7108
## 41.00       301.4362 -110.4428032 713.3152 -328.478388 931.3508
## 41.20       277.8965 -135.7406389 691.5336 -354.706892 910.4998
## 41.40       272.1022 -143.2049114 687.4092 -363.055199 907.2595
## 41.60       334.3896  -82.5798717 751.3590 -303.310160 972.0893
## 41.80       272.5989 -146.0913788 691.2891 -367.732607 912.9303
## 42.00       301.4468 -121.6929270 724.5865 -345.689564 948.5832
## 42.20       277.9070 -146.9934458 702.8075 -371.922172 927.7362
## 42.40       272.1127 -154.4606426 698.6861 -380.274951 924.5004
## 42.60       334.4001  -93.8387048 762.6390 -320.534657 989.3349
## 42.80       272.6094 -157.3538046 702.5727 -384.962598 930.1815
```

```
#9. Forecast for the next 180 business days. (6 months)
forecast_result_fit2 <- forecast(fit2, h = 180, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 6 month ahead", xlab = "Day", yla
```




```
print(forecast_result_fit2)
```

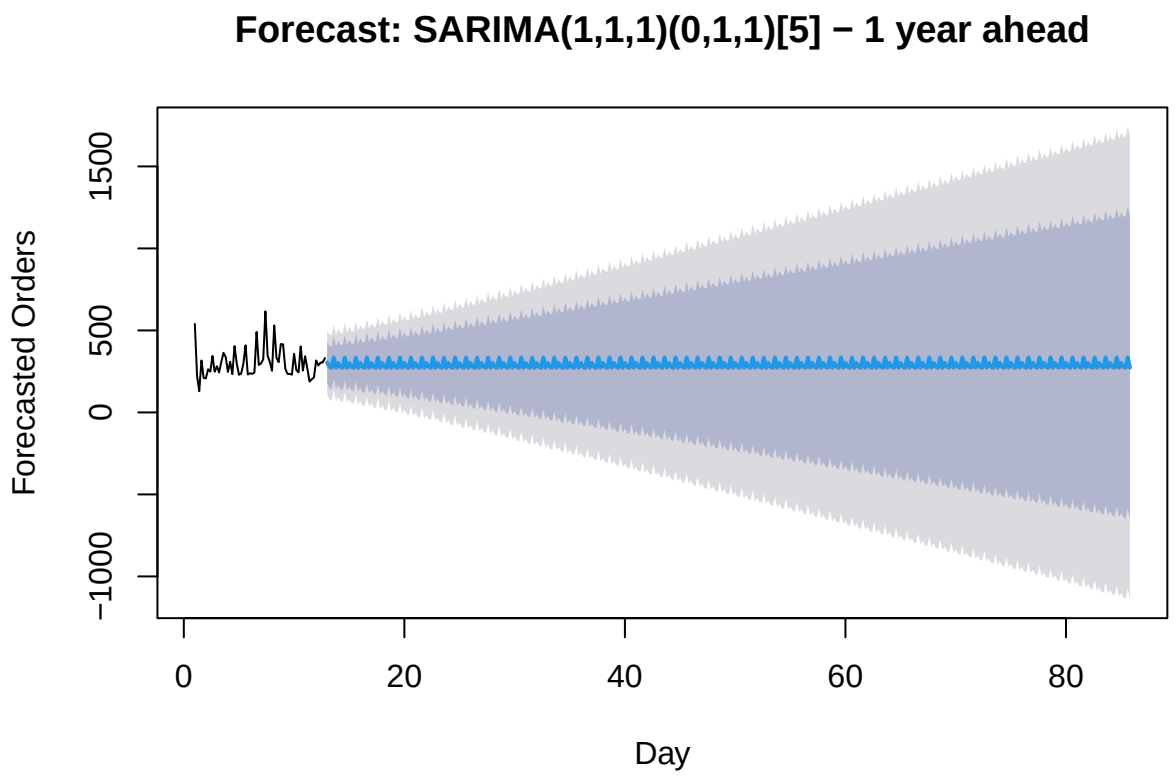
```
##       Point Forecast        Lo 80    Hi 80       Lo 95     Hi 95
## 13.00       305.0187  178.1410388 431.8963  110.976071  499.0613
## 13.20       277.8528  148.8138204 406.8917   80.504723  475.2008
## 13.40       271.8225  141.7189107 401.9262   72.846209  470.7989
## 13.60       334.0946  202.9906030 465.1986  133.588344  534.6008
## 13.80       272.3029  140.1898945 404.4159   70.253499  474.3523
## 14.00       301.1508  166.2322929 436.0692   94.810775  507.4907
## 14.20       277.6110  141.5091728 413.7128   69.461225  485.7607
## 14.40       271.8167  134.6126627 409.0207   61.981236  481.6522
## 14.60       334.1041  195.8094363 472.3988  122.600666  545.6075
## 14.80       272.3134  132.9117676 411.7150   59.117004  485.5098
## 15.00       301.1613  158.7219516 443.6007   83.319105  519.0035
## 15.20       277.6216  133.9150498 421.3281   57.841419  497.4017
## 15.40       271.8273  126.9379392 416.7166   50.238162  493.4164
## 15.60       334.1147  188.0547568 480.1746  110.735310  557.4940
## 15.80       272.3240  125.0732530 419.5747   47.123433  497.5245
## 16.00       301.1719  150.6861695 451.6576   71.023840  531.3199
## 16.20       277.6321  125.8085029 429.4558   45.437928  509.8263
## 16.40       271.8378  118.7630713 424.9126   37.730184  505.9455
## 16.60       334.1252  179.8119910 488.4385   98.123491  570.1270
## 16.80       272.3345  116.7590646 427.9100   34.402382  510.2667
## 17.00       301.1825  142.2047043 460.1602   58.046961  544.3180
## 17.20       277.6427  117.2673192 438.0181   32.369718  522.9157
```

```
## 17.40       271.8484  110.1640019 433.5328   24.573445  519.1234
## 17.60       334.1358  171.1552721 497.1164   84.878584  583.3930
## 17.80       272.3451  108.0414892 436.6487   21.064404  523.6258
## 18.00       301.1930  133.3451885 469.0409   44.491904  557.8942
## 18.20       277.6533  108.3573512 446.9492   18.737501  536.5691
## 18.40       271.8590  101.2049230 442.5130   10.866119  532.8519
## 18.60       334.1464  162.1471677 506.1456   71.096281  597.1965
## 18.80       272.3557   98.9814391 445.7299    7.202656  537.5087
## 19.00       301.2036  124.1644366 478.2428   30.445558  571.9617
## 19.20       277.6639   99.1338709 456.1938    4.625808  550.7019
## 19.40       271.8696   91.9396667 451.7995   -3.309465  547.0486
## 19.60       334.1570  152.8401039 515.4738   56.856758  611.4572
## 19.80       272.3663   89.6299060 455.1026   -7.104876  551.8374
## 20.00       301.2142  114.7099362 487.7184   15.980551  586.4478
## 20.20       277.6744   89.6430616 465.7058   -9.894729  565.2436
## 20.40       271.8801   82.4131967 461.3471  -17.884541  561.6448
## 20.60       334.1675  143.2778536 525.0572   42.226961  626.1081
## 20.80       272.3768   80.0294473 464.7242  -21.793108  566.5468
## 21.00       301.2248  105.0213011 497.4282    1.157465  601.2921
## 21.20       277.6850   79.9234506 475.4465  -24.765189  580.1352
## 21.40       271.8907   72.6630224 471.1184  -32.801742  576.5832
## 21.60       334.1781  133.4969319 534.8593   27.262735  641.0935
## 21.80       272.3874   70.2155607 474.5593  -36.807749  581.5826
## 22.00       301.2353   95.1315835 507.3391  -13.973150  616.4438
## 22.20       277.6956   70.0071935 485.3839  -39.936392  595.3275
## 22.40       271.9013   62.7204567 481.0821  -48.013182  591.8157
## 22.60       334.1887  123.5278281 544.8495   12.010709  656.3667
## 22.80       272.3980   60.2178907 484.5781  -52.103463  596.8994
## 23.00       301.2459   85.0684086 517.4234  -29.369045  631.8609
## 23.20       277.7061   59.9211784 495.4911  -55.367218  610.7795
## 23.40       271.9119   52.6116935 491.2120  -63.478798  607.3025
## 23.60       334.1993  113.3960565 555.0024   -3.490095  671.8886
## 23.80       272.4086   50.0612533 494.7559  -67.642297  612.4594
## 24.00       301.2565   74.8549291 527.6580  -44.994811  647.5078
## 24.20       277.7167   49.6879537 505.7455  -71.023182  626.4566
## 24.40       271.9224   42.3587102 501.4861  -79.164980  623.0098
## 24.60       334.2098  103.1230345 565.2966  -19.206924  687.6266
## 24.80       272.4191   39.7664886 505.0718  -83.392378  628.2306
## 25.00       301.2671   64.5106164 538.0235  -60.820669  663.3548
## 25.20       277.7273   39.3264947 516.1281  -86.875263  642.3298
## 25.40       271.9330   31.9800121 511.8860  -95.043426  638.9094
## 25.60       334.2204   92.7268060 575.7140  -35.112180  703.5530
## 25.80       272.4297   29.3511638 515.5082  -99.326840  644.1862
## 26.00       301.2776   54.0519095 548.5033  -76.821478  679.3767
## 26.20       277.7379   28.8528332 526.6229 -102.898943  658.3747
## 26.40       271.9436   21.4912436 522.3959 -111.090210  654.9774
## 26.60       334.2310   82.2226342 586.2393  -51.182522  719.6445
## 26.80       272.4403   18.8301470 526.0504 -115.422943  660.3035
## 27.00       301.2882   43.4927449 559.0836  -92.975924  695.5523
## 27.20       277.7484   18.2805698 537.2163 -119.073422  674.5703
## 27.40       271.9541   10.9056853 533.0026 -127.285021  671.1933
## 27.60       334.2415   71.6234843 596.8596  -67.398120  735.8812
## 27.80       272.4508    8.2160756 536.6856 -131.661362  676.5631
## 28.00       301.2988   32.8449881 569.7526 -109.265860  711.8634
```

```
## 28.20       277.7590    7.6212928 547.8967 -135.380976  690.8990
## 28.40       271.9647    0.2346598 543.6948 -143.610544  687.5400
## 28.60       334.2521   60.9404169 607.5638  -83.742058  752.2463
## 28.80       272.4614   -2.4802629 547.4031 -148.025597  692.9484
## 29.00       301.3093   22.1187853 580.4999 -125.675769  728.2945
## 29.20       277.7696   -3.1150822 558.6542 -151.806442  707.3456
## 29.40       271.9753  -10.5121377 554.4627 -160.051949  704.0025
## 29.60       334.2627   50.1829085 618.3425 -100.199845  768.7252
## 29.80       272.4720  -13.2496203 558.1936 -164.501505  709.4455
## 30.00       301.3199   11.3228492 591.3170 -142.192325  744.8322
## 30.20       277.7802  -13.9200337 569.4803 -168.336786  723.8971
## 30.40       271.9859  -21.3263706 565.2981 -176.596488  720.5682
## 30.60       334.2733   39.3591132 629.1874 -116.759008  785.3055
## 30.80       272.4826  -24.0840340 569.0492 -181.076908  726.0420
## 31.00       301.3305    0.4646939 602.1963 -158.804038  761.4650
## 31.20       277.7907  -24.7862082 580.3677 -184.960763  740.5422
## 31.40       271.9964  -32.2008398 576.1937 -193.233151  737.2260
## 31.60       334.2838   28.4760761 640.0916 -133.408774  801.9765
## 31.80       272.4931  -34.9766204 579.9629 -197.741278  742.7276
## 32.00       301.3411  -10.4491741 613.1313 -175.500955  778.1831
## 32.20       277.8013  -35.7072337 591.3098 -201.668627  757.2712
## 32.40       272.0070  -43.1293037 587.1433 -209.952391  753.9664
## 32.60       334.2944   17.5399095 651.0489 -150.139795  818.7286
## 32.80       272.5037  -45.9214038 590.9288 -214.485477  759.4929
## 33.00       301.3516  -21.4130978 624.1164 -192.274427  794.9777
## 33.20       277.8119  -46.6775665 602.3013 -218.451901  774.0757
## 33.40       272.0176  -54.1063290 598.1415 -226.745900  770.7811
## 33.60       334.3050    6.5559367 662.0540 -166.943929  835.5539
## 33.80       272.5143  -56.9131767 601.9417 -231.301540  776.3301
## 34.00       301.3622  -32.4221399 635.1466 -209.116901  811.8413
## 34.20       277.8224  -57.6923656 613.3373 -235.303179  790.9481
## 34.40       272.0282  -65.1271680 609.1835 -243.606415  787.6627
## 34.60       334.3156   -4.4711880 673.1023 -183.814058  852.4452
## 34.80       272.5249  -67.9473839 612.9971 -248.182501  793.2322
## 35.00       301.3728  -43.4719751 646.2175 -226.021762  828.7673
## 35.20       277.8330  -68.7473874 624.4134 -252.215973  807.8820
## 35.40       272.0387  -76.1876569 620.2651 -260.527570  804.6050
## 35.60       334.3261  -15.5373804 684.1896 -200.743935  869.3962
## 35.80       272.5354  -79.0200259 624.0909 -265.122242  810.1931
## 36.00       301.3834  -54.5588008 657.3255 -242.983196  845.7499
## 36.20       277.8436  -79.8388987 635.5261 -269.184573  824.8718
## 36.40       272.0493  -87.2841308 631.3827 -277.503760  821.6024
## 36.60       334.3367  -26.6390442 695.3125 -217.728062  886.4015
## 36.80       272.5460  -90.1275790 635.2196 -282.115376  827.2074
## 37.00       301.3939  -65.6792620 668.4671 -259.996071  862.7839
## 37.20       277.8542  -90.9636044 646.6719 -286.203939  841.9123
## 37.40       272.0599  -98.4133533 642.5331 -294.530034  838.6498
## 37.60       334.3473  -37.7730016 706.4676 -234.761578  903.4561
## 37.80       272.5566 -101.2669285 646.3801 -299.157138  844.2703
## 38.00       301.4045  -76.8303893 679.6394 -277.055846  879.8648
## 38.20       277.8647 -102.1185862 657.8481 -303.269609  858.9991
## 38.40       272.0704 -109.5724567 653.7134 -311.602007  855.7429
## 38.60       334.3578  -48.9364359 717.6521 -251.840174  920.5559
## 38.80       272.5671 -112.4353117 657.5696 -316.243303  861.3776
```

```
## 39.00       301.4151  -88.0095458 690.8397 -294.158487  896.9886
## 39.20       277.8753 -113.3012518 669.0519 -320.377617  876.1282
## 39.40       272.0810 -120.7588921 664.9209 -328.715781  872.8778
## 39.60       334.3684  -60.1268423 728.8637 -268.960021  937.6969
## 39.80       272.5777 -123.6302712 668.7857 -333.370113  878.5256
## 40.00       301.4256  -99.2143831 702.0657 -311.300404  914.1517
## 40.20       277.8859 -124.5092908 680.2811 -337.524430  893.2962
## 40.40       272.0916 -131.9703875 676.1536 -345.867880  890.0511
## 40.60       334.3790  -71.3419869 740.1000 -286.117701  954.8757
## 40.80       272.5883 -134.8496142 680.0262 -350.534215  895.7108
## 41.00       301.4362 -110.4428032 713.3152 -328.478388  931.3508
## 41.20       277.8965 -135.7406389 691.5336 -354.706892  910.4998
## 41.40       272.1022 -143.2049114 687.4092 -363.055199  907.2595
## 41.60       334.3896  -82.5798717 751.3590 -303.310160  972.0893
## 41.80       272.5989 -146.0913788 691.2891 -367.732607  912.9303
## 42.00       301.4468 -121.6929270 724.5865 -345.689564  948.5832
## 42.20       277.9070 -146.9934458 702.8075 -371.922172  927.7362
## 42.40       272.1127 -154.4606426 698.6861 -380.274951  924.5004
## 42.60       334.4001  -93.8387048 762.6390 -320.534657  989.3349
## 42.80       272.6094 -157.3538046 702.5727 -384.962598  930.1815
## 43.00       301.4574 -132.9630670 735.8778 -362.931353  965.8461
## 43.20       277.9176 -158.2660493 714.1013 -389.167729  945.0029
## 43.40       272.1233 -165.7359441 709.9826 -397.524634  941.7713
## 43.60       334.4107 -105.1168749 773.9383 -337.788726 1006.6102
## 43.80       272.6200 -168.6353082 713.8753 -402.221766  947.4618
## 44.00       301.4679 -144.2517032 747.1876 -380.201429  983.1373
## 44.20       277.9282 -169.5569519 725.4133 -406.441271  962.2976
## 44.40       272.1339 -177.0293408 721.2971 -414.801991  959.0698
## 44.60       334.4213 -116.4129294 785.2555 -355.070148 1023.9127
## 44.80       272.6306 -179.9344615 725.1956 -419.507927  964.7691
## 45.00       301.4785 -155.5574638 758.5145 -397.497695 1000.4547
## 45.20       277.9388 -180.8648014 736.7423 -423.740731  979.6182
## 45.40       272.1445 -188.3395000 732.6284 -432.104984  976.3939
## 45.60       334.4319 -127.7255558 796.5893 -372.376914 1041.2406
## 45.80       272.6412 -191.2499736 736.5323 -436.819106  982.1014
## 46.00       301.4891 -166.8791078 769.8573 -414.818253 1017.7964
## 46.20       277.9493 -192.1883737 748.0870 -441.064238  996.9629
## 46.40       272.1550 -199.6652153 743.9753 -449.431767  993.7418
## 46.60       334.4424 -139.0535652 807.9384 -389.707207 1058.5921
## 46.80       272.6517 -202.5806750 747.8841 -454.153516  999.4570
## 47.00       301.4997 -178.2155094 781.2148 -432.161380 1035.1607
## 47.20       277.9599 -203.5265587 759.4464 -458.410093 1014.3299
## 47.40       272.1656 -211.0053917 755.3366 -466.780668 1011.1119
## 47.60       334.4530 -150.3958783 819.3019 -407.059375 1075.9654
## 47.80       272.6623 -213.9255035 759.2501 -471.509531 1016.8341
## 48.00       301.5102 -189.5656457 792.5861 -449.525512 1052.5460
## 48.20       277.9705 -214.8783468 770.8193 -475.776751 1031.7177
## 48.40       272.1762 -222.3590334 766.7114 -484.150161 1028.5025
## 48.60       334.4636 -161.7515134 830.6787 -424.431917 1093.3591
## 48.80       272.6729 -225.2834928 770.6293 -488.885673 1034.2314
```

```
#10. Forecast for the next 365 days. (1 year)
forecast_result_fit2 <- forecast(fit2, h = 365, level = c(80, 95))
plot(forecast_result_fit2, main = "Forecast: SARIMA(1,1,1)(0,1,1)[5] - 1 year ahead", xlab = "Day", ylab
```




```
print(forecast_result_fit2)
```

```
##       Point Forecast        Lo 80     Hi 80        Lo 95     Hi 95
## 13.00       305.0187  178.1410388  431.8963   110.976071  499.0613
## 13.20       277.8528  148.8138204  406.8917    80.504723  475.2008
## 13.40       271.8225  141.7189107  401.9262    72.846209  470.7989
## 13.60       334.0946  202.9906030  465.1986   133.588344  534.6008
## 13.80       272.3029  140.1898945  404.4159    70.253499  474.3523
## 14.00       301.1508  166.2322929  436.0692    94.810775  507.4907
## 14.20       277.6110  141.5091728  413.7128    69.461225  485.7607
## 14.40       271.8167  134.6126627  409.0207    61.981236  481.6522
## 14.60       334.1041  195.8094363  472.3988   122.600666  545.6075
## 14.80       272.3134  132.9117676  411.7150    59.117004  485.5098
## 15.00       301.1613  158.7219516  443.6007    83.319105  519.0035
## 15.20       277.6216  133.9150498  421.3281    57.841419  497.4017
## 15.40       271.8273  126.9379392  416.7166    50.238162  493.4164
## 15.60       334.1147  188.0547568  480.1746   110.735310  557.4940
## 15.80       272.3240  125.0732530  419.5747    47.123433  497.5245
## 16.00       301.1719  150.6861695  451.6576    71.023840  531.3199
## 16.20       277.6321  125.8085029  429.4558    45.437928  509.8263
## 16.40       271.8378  118.7630713  424.9126    37.730184  505.9455
## 16.60       334.1252  179.8119910  488.4385    98.123491  570.1270
## 16.80       272.3345  116.7590646  427.9100    34.402382  510.2667
## 17.00       301.1825  142.2047043  460.1602    58.046961  544.3180
## 17.20       277.6427  117.2673192  438.0181    32.369718  522.9157
```

```
## 17.40       271.8484  110.1640019  433.5328    24.573445  519.1234
## 17.60       334.1358  171.1552721  497.1164    84.878584  583.3930
## 17.80       272.3451  108.0414892  436.6487    21.064404  523.6258
## 18.00       301.1930  133.3451885  469.0409    44.491904  557.8942
## 18.20       277.6533  108.3573512  446.9492    18.737501  536.5691
## 18.40       271.8590  101.2049230  442.5130    10.866119  532.8519
## 18.60       334.1464  162.1471677  506.1456    71.096281  597.1965
## 18.80       272.3557   98.9814391  445.7299     7.202656  537.5087
## 19.00       301.2036  124.1644366  478.2428    30.445558  571.9617
## 19.20       277.6639   99.1338709  456.1938     4.625808  550.7019
## 19.40       271.8696   91.9396667  451.7995    -3.309465  547.0486
## 19.60       334.1570  152.8401039  515.4738    56.856758  611.4572
## 19.80       272.3663   89.6299060  455.1026    -7.104876  551.8374
## 20.00       301.2142  114.7099362  487.7184    15.980551  586.4478
## 20.20       277.6744   89.6430616  465.7058    -9.894729  565.2436
## 20.40       271.8801   82.4131967  461.3471   -17.884541  561.6448
## 20.60       334.1675  143.2778536  525.0572    42.226961  626.1081
## 20.80       272.3768   80.0294473  464.7242   -21.793108  566.5468
## 21.00       301.2248  105.0213011  497.4282     1.157465  601.2921
## 21.20       277.6850   79.9234506  475.4465   -24.765189  580.1352
## 21.40       271.8907   72.6630224  471.1184   -32.801742  576.5832
## 21.60       334.1781  133.4969319  534.8593    27.262735  641.0935
## 21.80       272.3874   70.2155607  474.5593   -36.807749  581.5826
## 22.00       301.2353   95.1315835  507.3391   -13.973150  616.4438
## 22.20       277.6956   70.0071935  485.3839   -39.936392  595.3275
## 22.40       271.9013   62.7204567  481.0821   -48.013182  591.8157
## 22.60       334.1887  123.5278281  544.8495    12.010709  656.3667
## 22.80       272.3980   60.2178907  484.5781   -52.103463  596.8994
## 23.00       301.2459   85.0684086  517.4234   -29.369045  631.8609
## 23.20       277.7061   59.9211784  495.4911   -55.367218  610.7795
## 23.40       271.9119   52.6116935  491.2120   -63.478798  607.3025
## 23.60       334.1993  113.3960565  555.0024    -3.490095  671.8886
## 23.80       272.4086   50.0612533  494.7559   -67.642297  612.4594
## 24.00       301.2565   74.8549291  527.6580   -44.994811  647.5078
## 24.20       277.7167   49.6879537  505.7455   -71.023182  626.4566
## 24.40       271.9224   42.3587102  501.4861   -79.164980  623.0098
## 24.60       334.2098  103.1230345  565.2966   -19.206924  687.6266
## 24.80       272.4191   39.7664886  505.0718   -83.392378  628.2306
## 25.00       301.2671   64.5106164  538.0235   -60.820669  663.3548
## 25.20       277.7273   39.3264947  516.1281   -86.875263  642.3298
## 25.40       271.9330   31.9800121  511.8860   -95.043426  638.9094
## 25.60       334.2204   92.7268060  575.7140   -35.112180  703.5530
## 25.80       272.4297   29.3511638  515.5082   -99.326840  644.1862
## 26.00       301.2776   54.0519095  548.5033   -76.821478  679.3767
## 26.20       277.7379   28.8528332  526.6229  -102.898943  658.3747
## 26.40       271.9436   21.4912436  522.3959  -111.090210  654.9774
## 26.60       334.2310   82.2226342  586.2393   -51.182522  719.6445
## 26.80       272.4403   18.8301470  526.0504  -115.422943  660.3035
## 27.00       301.2882   43.4927449  559.0836   -92.975924  695.5523
## 27.20       277.7484   18.2805698  537.2163  -119.073422  674.5703
## 27.40       271.9541   10.9056853  533.0026  -127.285021  671.1933
## 27.60       334.2415   71.6234843  596.8596   -67.398120  735.8812
## 27.80       272.4508    8.2160756  536.6856  -131.661362  676.5631
## 28.00       301.2988   32.8449881  569.7526  -109.265860  711.8634
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## 28.20       277.7590    7.6212928  547.8967  -135.380976  690.8990
## 28.40       271.9647    0.2346598  543.6948  -143.610544  687.5400
## 28.60       334.2521   60.9404169  607.5638   -83.742058  752.2463
## 28.80       272.4614   -2.4802629  547.4031  -148.025597  692.9484
## 29.00       301.3093   22.1187853  580.4999  -125.675769  728.2945
## 29.20       277.7696   -3.1150822  558.6542  -151.806442  707.3456
## 29.40       271.9753  -10.5121377  554.4627  -160.051949  704.0025
## 29.60       334.2627   50.1829085  618.3425  -100.199845  768.7252
## 29.80       272.4720  -13.2496203  558.1936  -164.501505  709.4455
## 30.00       301.3199   11.3228492  591.3170  -142.192325  744.8322
## 30.20       277.7802  -13.9200337  569.4803  -168.336786  723.8971
## 30.40       271.9859  -21.3263706  565.2981  -176.596488  720.5682
## 30.60       334.2733   39.3591132  629.1874  -116.759008  785.3055
## 30.80       272.4826  -24.0840340  569.0492  -181.076908  726.0420
## 31.00       301.3305    0.4646939  602.1963  -158.804038  761.4650
## 31.20       277.7907  -24.7862082  580.3677  -184.960763  740.5422
## 31.40       271.9964  -32.2008398  576.1937  -193.233151  737.2260
## 31.60       334.2838   28.4760761  640.0916  -133.408774  801.9765
## 31.80       272.4931  -34.9766204  579.9629  -197.741278  742.7276
## 32.00       301.3411  -10.4491741  613.1313  -175.500955  778.1831
## 32.20       277.8013  -35.7072337  591.3098  -201.668627  757.2712
## 32.40       272.0070  -43.1293037  587.1433  -209.952391  753.9664
## 32.60       334.2944   17.5399095  651.0489  -150.139795  818.7286
## 32.80       272.5037  -45.9214038  590.9288  -214.485477  759.4929
## 33.00       301.3516  -21.4130978  624.1164  -192.274427  794.9777
## 33.20       277.8119  -46.6775665  602.3013  -218.451901  774.0757
## 33.40       272.0176  -54.1063290  598.1415  -226.745900  770.7811
## 33.60       334.3050    6.5559367  662.0540  -166.943929  835.5539
## 33.80       272.5143  -56.9131767  601.9417  -231.301540  776.3301
## 34.00       301.3622  -32.4221399  635.1466  -209.116901  811.8413
## 34.20       277.8224  -57.6923656  613.3373  -235.303179  790.9481
## 34.40       272.0282  -65.1271680  609.1835  -243.606415  787.6627
## 34.60       334.3156   -4.4711880  673.1023  -183.814058  852.4452
## 34.80       272.5249  -67.9473839  612.9971  -248.182501  793.2322
## 35.00       301.3728  -43.4719751  646.2175  -226.021762  828.7673
## 35.20       277.8330  -68.7473874  624.4134  -252.215973  807.8820
## 35.40       272.0387  -76.1876569  620.2651  -260.527570  804.6050
## 35.60       334.3261  -15.5373804  684.1896  -200.743935  869.3962
## 35.80       272.5354  -79.0200259  624.0909  -265.122242  810.1931
## 36.00       301.3834  -54.5588008  657.3255  -242.983196  845.7499
## 36.20       277.8436  -79.8388987  635.5261  -269.184573  824.8718
## 36.40       272.0493  -87.2841308  631.3827  -277.503760  821.6024
## 36.60       334.3367  -26.6390442  695.3125  -217.728062  886.4015
## 36.80       272.5460  -90.1275790  635.2196  -282.115376  827.2074
## 37.00       301.3939  -65.6792620  668.4671  -259.996071  862.7839
## 37.20       277.8542  -90.9636044  646.6719  -286.203939  841.9123
## 37.40       272.0599  -98.4133533  642.5331  -294.530034  838.6498
## 37.60       334.3473  -37.7730016  706.4676  -234.761578  903.4561
## 37.80       272.5566 -101.2669285  646.3801  -299.157138  844.2703
## 38.00       301.4045  -76.8303893  679.6394  -277.055846  879.8648
## 38.20       277.8647 -102.1185862  657.8481  -303.269609  858.9991
## 38.40       272.0704 -109.5724567  653.7134  -311.602007  855.7429
## 38.60       334.3578  -48.9364359  717.6521  -251.840174  920.5559
## 38.80       272.5671 -112.4353117  657.5696  -316.243303  861.3776
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## 39.00       301.4151  -88.0095458  690.8397  -294.158487  896.9886
## 39.20       277.8753 -113.3012518  669.0519  -320.377617  876.1282
## 39.40       272.0810 -120.7588921  664.9209  -328.715781  872.8778
## 39.60       334.3684  -60.1268423  728.8637  -268.960021  937.6969
## 39.80       272.5777 -123.6302712  668.7857  -333.370113  878.5256
## 40.00       301.4256  -99.2143831  702.0657  -311.300404  914.1517
## 40.20       277.8859 -124.5092908  680.2811  -337.524430  893.2962
## 40.40       272.0916 -131.9703875  676.1536  -345.867880  890.0511
## 40.60       334.3790  -71.3419869  740.1000  -286.117701  954.8757
## 40.80       272.5883 -134.8496142  680.0262  -350.534215  895.7108
## 41.00       301.4362 -110.4428032  713.3152  -328.478388  931.3508
## 41.20       277.8965 -135.7406389  691.5336  -354.706892  910.4998
## 41.40       272.1022 -143.2049114  687.4092  -363.055199  907.2595
## 41.60       334.3896  -82.5798717  751.3590  -303.310160  972.0893
## 41.80       272.5989 -146.0913788  691.2891  -367.732607  912.9303
## 42.00       301.4468 -121.6929270  724.5865  -345.689564  948.5832
## 42.20       277.9070 -146.9934458  702.8075  -371.922172  927.7362
## 42.40       272.1127 -154.4606426  698.6861  -380.274951  924.5004
## 42.60       334.4001  -93.8387048  762.6390  -320.534657  989.3349
## 42.80       272.6094 -157.3538046  702.5727  -384.962598  930.1815
## 43.00       301.4574 -132.9630670  735.8778  -362.931353  965.8461
## 43.20       277.9176 -158.2660493  714.1013  -389.167729  945.0029
## 43.40       272.1233 -165.7359441  709.9826  -397.524634  941.7713
## 43.60       334.4107 -105.1168749  773.9383  -337.788726 1006.6102
## 43.80       272.6200 -168.6353082  713.8753  -402.221766  947.4618
## 44.00       301.4679 -144.2517032  747.1876  -380.201429  983.1373
## 44.20       277.9282 -169.5569519  725.4133  -406.441271  962.2976
## 44.40       272.1339 -177.0293408  721.2971  -414.801991  959.0698
## 44.60       334.4213 -116.4129294  785.2555  -355.070148 1023.9127
## 44.80       272.6306 -179.9344615  725.1956  -419.507927  964.7691
## 45.00       301.4785 -155.5574638  758.5145  -397.497695 1000.4547
## 45.20       277.9388 -180.8648014  736.7423  -423.740731  979.6182
## 45.40       272.1445 -188.3395000  732.6284  -432.104984  976.3939
## 45.60       334.4319 -127.7255558  796.5893  -372.376914 1041.2406
## 45.80       272.6412 -191.2499736  736.5323  -436.819106  982.1014
## 46.00       301.4891 -166.8791078  769.8573  -414.818253 1017.7964
## 46.20       277.9493 -192.1883737  748.0870  -441.064238  996.9629
## 46.40       272.1550 -199.6652153  743.9753  -449.431767  993.7418
## 46.60       334.4424 -139.0535652  807.9384  -389.707207 1058.5921
## 46.80       272.6517 -202.5806750  747.8841  -454.153516  999.4570
## 47.00       301.4997 -178.2155094  781.2148  -432.161380 1035.1607
## 47.20       277.9599 -203.5265587  759.4464  -458.410093 1014.3299
## 47.40       272.1656 -211.0053917  755.3366  -466.780668 1011.1119
## 47.60       334.4530 -150.3958783  819.3019  -407.059375 1075.9654
## 47.80       272.6623 -213.9255035  759.2501  -471.509531 1016.8341
## 48.00       301.5102 -189.5656457  792.5861  -449.525512 1052.5460
## 48.20       277.9705 -214.8783468  770.8193  -475.776751 1031.7177
## 48.40       272.1762 -222.3590334  766.7114  -484.150161 1028.5025
## 48.60       334.4636 -161.7515134  830.6787  -424.431917 1093.3591
## 48.80       272.6729 -225.2834928  770.6293  -488.885673 1034.2314
## 49.00       301.5208 -200.9285850  803.9702  -466.909226 1069.9508
## 49.20       277.9810 -226.2428185  782.2049  -493.162808 1049.1249
## 49.40       272.1868 -233.7252331  778.0987  -501.538861 1045.9124
## 49.60       334.4742 -173.1195757  842.0679  -441.823465 1110.7718
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## 49.80       272.6835 -236.6537615  782.0207  -506.280596 1051.6475
## 50.00       301.5314 -212.3034773  815.3662  -484.311219 1087.3740
## 50.20       277.9916 -237.6191343  793.6024  -510.566979 1066.5502
## 50.40       272.1973 -245.1031622  789.4978  -518.945499 1063.3401
## 50.60       334.4847 -184.4992476  853.4687  -459.232768 1128.2022
## 50.80       272.6940 -248.0355046  793.4236  -523.693067 1069.0811
## 51.00       301.5420 -223.6895452  826.7734  -501.730304 1104.8142
## 51.20       278.0022 -249.0065265  805.0109  -527.988089 1083.9925
## 51.40       272.2079 -256.4920629  800.9079  -536.368916 1080.7847
## 51.60       334.4953 -195.8897814  864.8804  -476.658683 1145.6493
## 51.80       272.7046 -259.4279851  804.8372  -541.121959 1086.5312
## 52.00       301.5525 -235.0860767  838.1911  -519.165392 1122.2704
## 52.20       278.0128 -260.4042917  816.4298  -545.425064 1101.4506
## 52.40       272.2185 -267.8912403  812.3282  -553.808051 1098.2450
## 52.60       334.5059 -207.2904912  876.3022  -494.100162 1163.1119
## 52.80       272.7152 -270.8305273  816.2609  -558.566240 1103.9966
## 53.00       301.5631 -246.4924184  849.6186  -536.615484 1139.7417
## 53.20       278.0233 -271.8117843  827.8585  -562.876915 1118.9236
## 53.40       272.2290 -279.3000568  823.7581  -571.261927 1115.7200
## 53.60       334.5164 -218.7007475  887.7336  -511.556240 1180.5891
## 53.80       272.7257 -282.2425105  827.6940  -576.024959 1121.4764
## 54.00       301.5737 -257.9079699  861.0553  -554.079660 1157.2270
## 54.20       278.0339 -283.2284105  839.2962  -580.342736 1136.4106
## 54.40       272.2396 -290.7179257  835.1972  -588.729648 1133.2089
## 54.60       334.5270 -230.1199709  899.1740  -529.026032 1198.0801
## 54.80       272.7363 -293.6633634  839.1360  -593.497243 1138.9699
## 55.00       301.5842 -269.3321782  872.5007  -571.557076 1174.7256
## 55.20       278.0445 -294.6536237  850.7426  -597.821688 1153.9107
## 55.40       272.2502 -302.1443069  846.6447  -606.210387 1150.7108
## 55.60       334.5376 -241.5476277  910.6228  -546.508722 1215.5839
## 55.80       272.7469 -305.0925596  850.5863  -610.982287 1156.4761
## 56.00       301.5948 -280.7645333  883.9542  -589.046951 1192.2366
## 56.20       278.0551 -306.0869195  862.1970  -615.313002 1171.4231
## 56.40       272.2608 -313.5787016  858.1002  -623.703381 1168.2249
## 56.60       334.5482 -252.9832255  922.0796  -564.003556 1233.0999
## 56.80       272.7575 -316.5296134  862.0445  -628.479349 1173.9943
## 57.00       301.6054 -292.2045643  895.4153  -606.548566 1209.7593
## 57.20       278.0656 -317.5278322  873.6591  -632.815965 1188.9472
## 57.40       272.2713 -325.0206493  869.5633  -641.207927 1185.7506
## 57.60       334.5587 -264.4263089  933.5438  -581.509839 1250.6273
## 57.80       272.7680 -327.9740754  873.5102  -645.987740 1191.5238
## 58.00       301.6160 -303.6518356  906.8838  -624.061254 1227.2932
## 58.20       278.0762 -328.9759305  885.1283  -650.329918 1206.4823
## 58.40       272.2819 -336.4697238  881.0335  -658.723373 1203.2872
## 58.60       334.5693 -275.8764566  945.0151  -599.026926 1268.1655
## 58.80       272.7786 -339.4255299  884.9828  -663.506826 1209.0640
## 59.00       301.6265 -315.1059437  918.3590  -641.584397 1244.8375
## 59.20       278.0868 -340.4308152  896.6044  -667.854249 1224.0278
## 59.40       272.2925 -347.9255300  892.5105  -676.249114 1220.8341
## 59.60       334.5799 -287.3332782  956.4930  -616.554220 1285.7140
## 59.80       272.7892 -350.8835913  896.4620  -681.036015 1226.6144
## 60.00       301.6371 -326.5665141  929.8407  -659.117424 1262.3916
## 60.20       278.0973 -351.8921158  908.0868  -685.388393 1241.5831
## 60.40       272.3031 -359.3877013  903.9938  -693.784589 1238.3907
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## 60.60       334.5905 -298.7964111  967.9773  -634.091166 1303.2721
## 60.80       272.7998 -362.3479018  907.9474  -698.574762 1244.1743
## 61.00       301.6477 -338.0331994  941.3286  -676.659803 1279.9552
## 61.20       278.1079 -363.3594881  919.5753  -702.931823 1259.1477
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## 63.00       301.6688 -360.9836434  964.3213  -711.770673 1315.1083
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## 63.40       272.3348 -393.8091166  938.4787  -746.444392 1291.1139
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## 64.40       272.3453 -405.2935696  949.9843  -764.013944 1308.7046
## 64.60       334.6328 -344.7056578 1013.9712  -704.325688 1373.5912
## 64.80       272.8420 -408.2613153  953.9454  -768.815657 1314.4998
## 65.00       301.6900 -383.9549450  987.3349  -746.913441 1350.2934
## 65.20       278.1502 -409.2836089  965.5840  -773.189093 1329.4895
## 65.40       272.3559 -416.7829028  961.4947  -781.590960 1326.3028
## 65.60       334.6433 -356.1957337 1025.4824  -721.903840 1391.1905
## 65.80       272.8526 -419.7523140  965.4576  -786.395220 1332.1005
## 66.00       301.7005 -395.4477726  998.8489  -764.495801 1367.8969
## 66.20       278.1608 -420.7769498  977.0985  -790.772238 1347.0938
## 66.40       272.3665 -428.2768758  973.0099  -799.175072 1343.9081
## 66.60       334.6539 -367.6904139 1036.9982  -739.489033 1408.7968
## 66.80       272.8632 -431.2478752  976.9743  -803.981761 1349.7082
## 67.00       301.7111 -406.9450742 1010.3673  -782.085003 1385.5072
## 67.20       278.1714 -432.2747368  988.6175  -808.362183 1364.7049
## 67.40       272.3771 -439.7752638  984.5294  -816.765936 1361.5201
## 67.60       334.6645 -379.1894757 1048.5184  -757.080928 1426.4099
## 67.80       272.8738 -442.7477789  988.4953  -821.574943 1367.3225
## 68.00       301.7217 -418.4466352 1021.8900  -799.680720 1403.1241
## 68.20       278.1819 -443.7767571 1000.1406  -825.958602 1382.3225
## 68.40       272.3876 -451.2778561  996.0531  -834.363230 1379.1385
## 68.60       334.6750 -390.6927106 1060.0428  -774.679204 1444.0293
## 68.80       272.8843 -454.2518189 1000.0205  -839.174451 1384.9431
## 69.00       301.7323 -429.9522546 1033.4168  -817.282644 1420.7472
## 69.20       278.1925 -455.2828116 1011.6678  -843.561191 1399.9462
## 69.40       272.3982 -462.7844552 1007.5809  -851.966652 1396.7631
## 69.60       334.6856 -402.1999230 1071.5712  -792.283564 1461.6548
## 69.80       272.8949 -465.7598018 1011.5496  -856.779989 1402.5698
## 70.00       301.7428 -441.4617439 1044.9474  -834.890485 1438.3762
## 70.20       278.2031 -466.7927131 1023.1989  -861.169663 1417.5758
## 70.40       272.4088 -474.2948758 1019.1125  -869.575918 1414.3935
## 70.60       334.6962 -413.7109293 1083.1033  -809.893726 1479.2861
## 70.80       272.9055 -477.2715459 1023.0825  -874.391279 1420.2023
## 71.00       301.7534 -452.9749257 1056.4818  -852.503975 1456.0108
## 71.20       278.2137 -478.3062859 1034.7336  -878.783750 1435.2111
```

```
## 71.40       272.4194 -485.8089436 1030.6477  -887.190762 1432.0295
## 71.60       334.7068 -425.2255568 1094.6391  -827.509426 1496.9229
## 71.80       272.9161 -488.7868806 1034.6190  -892.008061 1437.8402
## 72.00       301.7640 -464.4916335 1068.0196  -870.122856 1473.6508
## 72.20       278.2242 -489.8233648 1046.2718  -896.403199 1452.8517
## 72.40       272.4299 -497.3264949 1042.1864  -904.810934 1449.6708
## 72.60       334.7173 -436.7436434 1106.1783  -845.130417 1514.5651
## 72.80       272.9266 -500.3056454 1046.1589  -909.630089 1455.4834
## 73.00       301.7746 -476.0117106 1079.5608  -887.746891 1491.2960
## 73.20       278.2348 -501.3437941 1057.8134  -914.027773 1470.4974
## 73.40       272.4405 -508.8473754 1053.7284  -922.436197 1467.3172
## 73.60       334.7279 -448.2650363 1117.7209  -862.756463 1532.2123
## 73.80       272.9372 -511.8276890 1057.7021  -927.257131 1473.1315
## 74.00       301.7851 -487.5350092 1091.1053  -905.375852 1508.9461
## 74.20       278.2454 -512.8674276 1069.3582  -931.657246 1488.1480
## 74.40       272.4511 -520.3714399 1065.2736  -940.066330 1484.9685
## 74.60       334.7385 -459.7895914 1129.2666  -880.387347 1549.8643
## 74.80       272.9478 -523.3528690 1069.2484  -944.888969 1490.7845
## 75.00       301.7957 -499.0613903 1102.6528  -923.009528 1526.6009
## 75.20       278.2559 -524.3941269 1080.9060  -949.291409 1505.8033
## 75.40       272.4617 -531.8985515 1076.8219  -957.701123 1502.6244
## 75.60       334.7491 -471.3171731 1140.8153  -898.022859 1567.5210
## 75.80       272.9584 -534.8810510 1080.7978  -962.525399 1508.4421
## 76.00       301.8063 -510.5907225 1114.2033  -940.647717 1544.2603
## 76.20       278.2665 -535.9237618 1092.4568  -966.930061 1523.4631
## 76.40       272.4722 -543.4285808 1088.3730  -975.340378 1520.2848
## 76.60       334.7596 -482.8476532 1152.3669  -915.662803 1585.1821
## 76.80       272.9689 -546.4121083 1092.3500  -980.166227 1526.1041
## 77.00       301.8169 -522.1228818 1125.7566  -958.290230 1561.9239
## 77.20       278.2771 -547.4562092 1104.0104  -984.573014 1541.1272
## 77.40       272.4828 -554.9614059 1099.9270  -992.983909 1537.9495
## 77.60       334.7702 -494.3809108 1163.9213  -933.306995 1602.8474
## 77.80       272.9795 -557.9459211 1103.9049  -997.811268 1543.7703
## 78.00       301.8274 -533.6577511 1137.3126  -975.936887 1579.5917
## 78.20       278.2877 -558.9913529 1115.5667 -1002.220091 1558.7954
## 78.40       272.4934 -566.4969112 1111.4837 -1010.631539 1555.6183
## 78.60       334.7808 -505.9168313 1175.4784  -950.955261 1620.5168
## 78.80       272.9901 -569.4823760 1115.4625 -1015.460351 1561.4405
## 79.00       301.8380 -545.1952196 1148.8712  -993.587520 1597.2635
## 79.20       278.2982 -570.5290828 1127.1256 -1019.871123 1576.4676
## 79.40       272.5039 -578.0349878 1123.0429 -1028.283101 1573.2910
## 79.60       334.7913 -517.4553066 1187.0380  -968.607433 1638.1901
## 79.80       273.0006 -581.0213659 1127.0227 -1033.113310 1579.1146
## 80.00       301.8486 -556.7351823 1160.4323 -1011.241967 1614.9391
## 80.20       278.3088 -582.0692947 1138.6869 -1037.525951 1594.1436
## 80.40       272.5145 -589.5755322 1134.6046 -1045.938438 1590.9675
## 80.60       334.8019 -528.9962342 1198.6001  -986.263355 1655.8672
## 80.80       273.0112 -592.5627895 1138.5852 -1050.769991 1596.7924
## 81.00       301.8591 -568.2775400 1171.9958 -1028.900077 1632.6184
## 81.20       278.3194 -593.6118901 1150.2507 -1055.184425 1611.8232
## 81.40       272.5251 -601.1184466 1146.1686 -1063.597399 1608.6476
## 81.60       334.8125 -540.5395171 1210.1645 -1003.922880 1673.5479
## 81.80       273.0218 -604.1065504 1150.1501 -1068.430247 1614.4738
## 82.00       301.8697 -579.8221985 1183.5616 -1046.561705 1650.3011
```

```
## 82.20       278.3300 -605.1567754 1161.8167 -1072.846400 1629.5063
## 82.40       272.5357 -612.6636382 1157.7350 -1081.259843 1626.3312
## 82.60       334.8231 -552.0850632 1221.7312 -1021.585866 1691.2320
## 82.80       273.0324 -615.6525575 1161.7173 -1086.093938 1632.1587
## 83.00       301.8803 -591.3690686 1195.1296 -1064.226716 1667.9873
## 83.20       278.3405 -616.7038620 1173.3849 -1090.511742 1647.1928
## 83.40       272.5462 -624.2110189 1169.3035 -1098.925635 1644.0181
## 83.60       334.8336 -563.6327851 1233.3001 -1039.252180 1708.9195
## 83.80       273.0429 -627.2007245 1173.2866 -1103.760932 1649.8468
## 84.00       301.8909 -602.9180655 1206.6998 -1081.894980 1685.6767
## 84.20       278.3511 -628.2530656 1184.9553 -1108.180322 1664.8825
## 84.40       272.5568 -635.7605053 1180.8741 -1116.594647 1661.7083
## 84.60       334.8442 -575.1826001 1244.8710 -1056.921695 1726.6101
## 84.80       273.0535 -638.7509690 1184.8580 -1121.431104 1667.5381
## 85.00       301.9014 -614.4691088 1218.2720 -1099.566373 1703.3692
## 85.20       278.3617 -639.8043065 1196.5277 -1125.852018 1682.5754
## 85.40       272.5674 -647.3120179 1192.4468 -1134.266758 1679.4015
## 85.60       334.8548 -586.7344293 1256.4440 -1074.594290 1744.3039
## 85.80       273.0641 -650.3032132 1196.4314 -1139.104334 1685.2325
```

#9. External Variables for improving process.

Interpretation:

I wanted to look the difference between the original seasonal time series and time series with external variables. The regression SARIMA Model 2 forecast for the next 60 days with urgent orders and non-urgent orders has a similar visualization with original SARIMA Model. I think the original SARIMA Model is strong and well-indicated. The SARIMA Model 2 has lower AIC, BIC values but they are really similar visualization. Therefore, it did not change the main seasonal pattern and forecast trend. In conclusion, the primary seasonal ARIMA model explains the most of the variation in total orders and the external variables did not do well but the statistical goodness of fitness measurement was improved based on lower AIC, BIC values.

```r
# Data set setting.
ts_data <- ts(miles2$Target..Total.orders., frequency = 5) # Original data.

# Add two external objects, urgent and non-urgent orders.
nonurgent_ts <- miles2$Non.urgent.order
urgent_ts <- miles2$Urgent.order
xreg_vars <- cbind(urgent_ts, nonurgent_ts) # Design matrix for two external variables.

print(nonurgent_ts)
```

```
##  [1] 316.307 128.633  43.651 171.297  90.532 110.925 144.124 119.379 218.856
## [10] 146.518 178.433 145.865 170.566 220.343 193.768 122.736 144.051 105.415
## [19] 240.660 131.067 130.129 123.286 190.816 266.741 123.143 148.139 118.552
## [28] 146.959 299.770 151.341 206.206 170.868 435.304 235.106 168.179 172.783
## [37] 381.768 221.438 193.957 275.076 252.298 165.472 126.030 112.246 123.302
## [46] 187.810 119.863 127.805 120.629 130.465 222.282 150.257  96.494  89.526
## [55] 134.425 158.716 150.784 193.534 196.555 192.116
```

```r
print(urgent_ts)
```

```
##  [1] 223.270  96.042  84.375 127.667 113.526  96.360 118.919 113.870 124.381
## [10] 101.045 102.793  91.180 114.412 141.406 141.854 124.256 158.408 108.688
## [19] 163.720 166.649  98.927 103.551  87.629 141.437 106.083  85.310 100.417
## [28]  95.153 133.375 131.788  92.160 131.463 181.149 110.874 125.119  77.371
## [37] 140.041 111.392 111.859 121.697 150.708 102.530 108.055 106.641  94.315
## [46] 167.455 139.383 114.813 112.703 105.273 120.324 116.959  87.294  99.756
## [55]  79.084 158.133 133.069 109.639 108.395 121.106
```

```r
print(xreg_vars)
```

```
##       urgent_ts nonurgent_ts
##  [1,]   223.270      316.307
##  [2,]    96.042      128.633
##  [3,]    84.375       43.651
##  [4,]   127.667      171.297
##  [5,]   113.526       90.532
##  [6,]    96.360      110.925
##  [7,]   118.919      144.124
##  [8,]   113.870      119.379
##  [9,]   124.381      218.856
## [10,]   101.045      146.518
## [11,]   102.793      178.433
## [12,]    91.180      145.865
## [13,]   114.412      170.566
## [14,]   141.406      220.343
## [15,]   141.854      193.768
## [16,]   124.256      122.736
## [17,]   158.408      144.051
## [18,]   108.688      105.415
## [19,]   163.720      240.660
## [20,]   166.649      131.067
## [21,]    98.927      130.129
## [22,]   103.551      123.286
## [23,]    87.629      190.816
## [24,]   141.437      266.741
## [25,]   106.083      123.143
## [26,]    85.310      148.139
## [27,]   100.417      118.552
## [28,]    95.153      146.959
## [29,]   133.375      299.770
## [30,]   131.788      151.341
## [31,]    92.160      206.206
## [32,]   131.463      170.868
## [33,]   181.149      435.304
## [34,]   110.874      235.106
## [35,]   125.119      168.179
## [36,]    77.371      172.783
## [37,]   140.041      381.768
## [38,]   111.392      221.438
## [39,]   111.859      193.957
```

```
## [40,]   121.697      275.076
## [41,]   150.708      252.298
## [42,]   102.530      165.472
## [43,]   108.055      126.030
## [44,]   106.641      112.246
## [45,]    94.315      123.302
## [46,]   167.455      187.810
## [47,]   139.383      119.863
## [48,]   114.813      127.805
## [49,]   112.703      120.629
## [50,]   105.273      130.465
## [51,]   120.324      222.282
## [52,]   116.959      150.257
## [53,]    87.294       96.494
## [54,]    99.756       89.526
## [55,]    79.084      134.425
## [56,]   158.133      158.716
## [57,]   133.069      150.784
## [58,]   109.639      193.534
## [59,]   108.395      196.555
## [60,]   121.106      192.116
```

```
# Fit the SARIMA Model2 with external variables - dynamic regression.
fit_regression_sarima2 <- Arima(ts_data,
                                order = c(1,1,1),
                                seasonal = list(order = c(0,1,1), period = 5),
                                xreg = xreg_vars)
fit_regression_sarima2
```

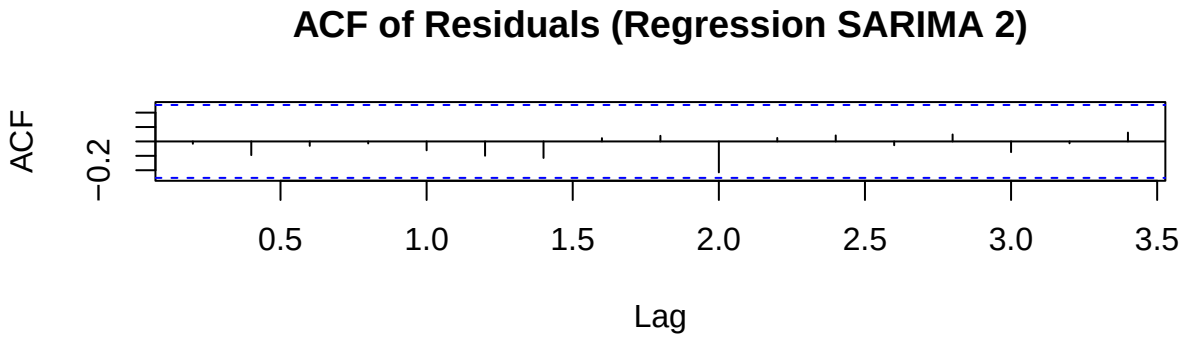
```
## Series: ts_data
## Regression with ARIMA(1,1,1)(0,1,1)[5] errors
##
## Coefficients:
##           ar1     ma1     sma1  urgent_ts  nonurgent_ts
##       -0.0013  -1.000  -0.9999     1.0068        0.9652
## s.e.   0.1368   0.099   0.4106     0.1355        0.0531
##
## sigma^2 = 568.4:  log likelihood = -254.76
## AIC=521.51   AICc=523.3   BIC=533.44
```

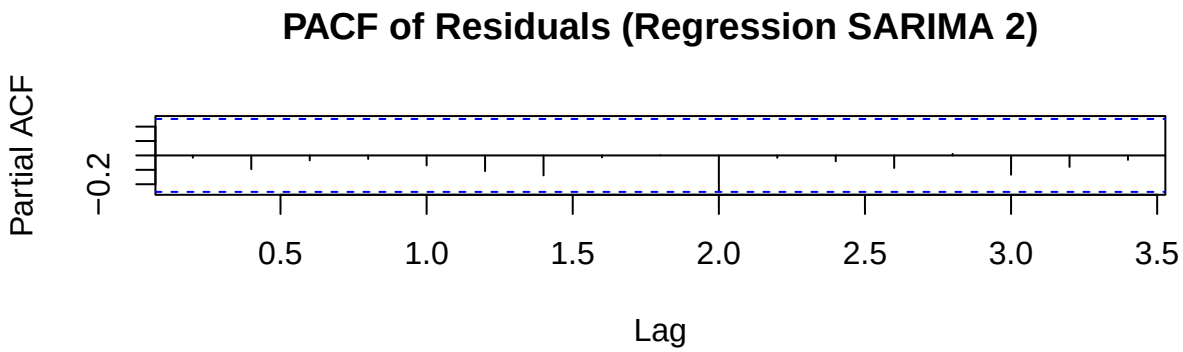
```
summary(fit_regression_sarima2) # lower AIC, BIC than original SARIMA Model.
```

```
## Series: ts_data
## Regression with ARIMA(1,1,1)(0,1,1)[5] errors
##
## Coefficients:
##           ar1     ma1     sma1  urgent_ts  nonurgent_ts
##       -0.0013  -1.000  -0.9999     1.0068        0.9652
## s.e.   0.1368   0.099   0.4106     0.1355        0.0531
##
## sigma^2 = 568.4:  log likelihood = -254.76
## AIC=521.51   AICc=523.3   BIC=533.44
##
```

```
## Training set error measures:
##                       ME     RMSE      MAE        MPE     MAPE      MASE
## Training set -0.6055959 21.54608 10.44677 -0.6647723 3.346938 0.1242899
##                      ACF1
## Training set -0.01618282
```

```
# Check process for residual diagnostics.
par(mfrow = c(2,1))
acf(residuals(fit_regression_sarima2), main = "ACF of Residuals (Regression SARIMA 2)") # White Noise a
pacf(residuals(fit_regression_sarima2), main = "PACF of Residuals (Regression SARIMA 2)") # Similar wit
```



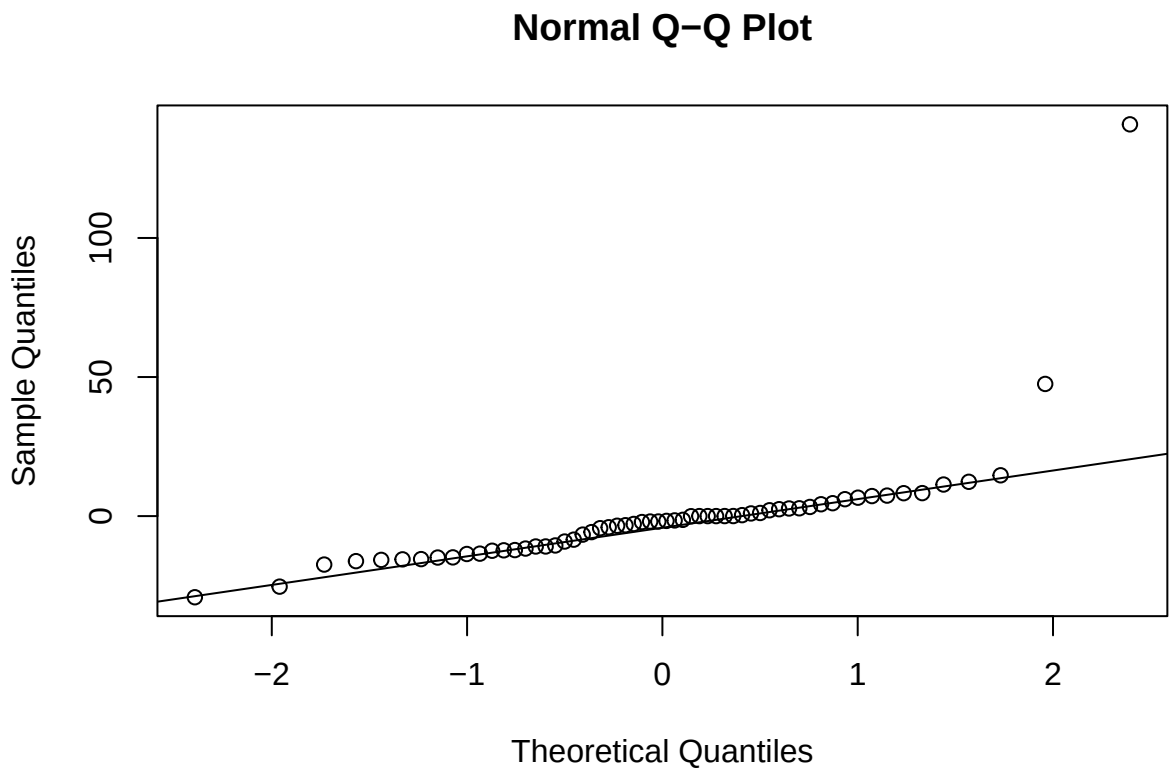



```
                                                                                    # the residua
par(mfrow = c(1,1))

Box.test(residuals(fit_regression_sarima2), lag = 10, type = "Ljung-Box") # Higher P-value than signifi
```

```
##
##  Box-Ljung test
##
## data:  residuals(fit_regression_sarima2)
## X-squared = 6.1044, df = 10, p-value = 0.8064
```

```
# Normal Q-Q Plot.
qqnorm(residuals(fit_regression_sarima2)); qqline(residuals(fit_regression_sarima2), col = "black")
```

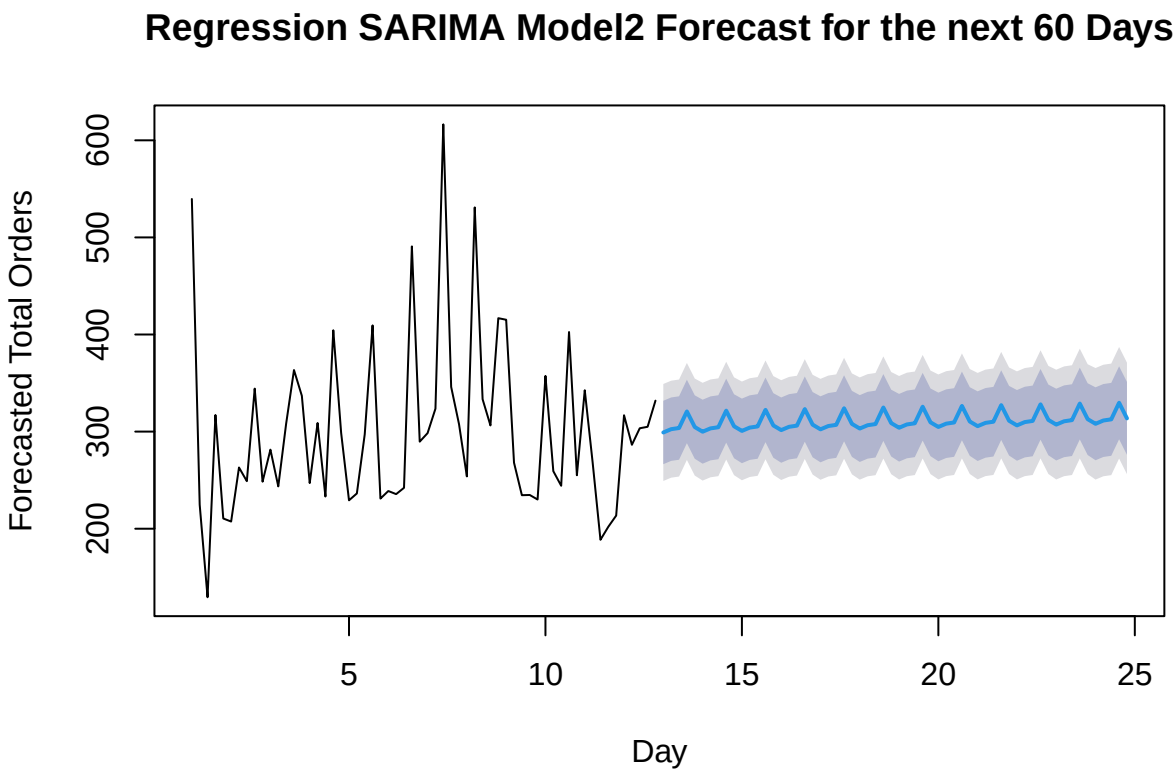



```
# Forecast with external variables for the next 60 days.
future_nonurgent <- rep(mean(nonurgent_ts), 60)
future_urgent <- rep(mean(urgent_ts), 60)
future_xreg <- cbind(future_urgent, future_nonurgent)

forecast_regression_sarima2 <- forecast(fit_regression_sarima2,
                                        h = 60,
                                        xreg = future_xreg,
                                        level = c(80,95))
```

```
## Warning in forecast.forecast_ARIMA(fit_regression_sarima2, h = 60, xreg =
## future_xreg, : xreg contains different column names from the xreg used in
## training. Please check that the regressors are in the same order.
```

```
# Visualization.
plot(forecast_regression_sarima2, main = "Regression SARIMA Model2 Forecast for the next 60 Days",
     xlab = "Day", ylab = "Forecasted Total Orders")
```



#10. Report for Seasonal ARIMA Modeling with "Daily Demand Forecasting Orders" data set:

Conclusion: The SARIMA Model 2 with original data is the most appropriate suitable model for forecasting seasonal demand due to statitsically appropriate fit. This is based on Model 2 having the lowest AIC, BIC, p-value, proper stationarity handling in (d=1, D=1), and reasonable normality. The result between regression SARIMA Model2 with external variables and SARIMA Model 2 with original data is that the SARIMA Model 2 with original data already shows the most of seasonal behavior and trend in total orders. Despite the SARIMA Model 2 with external variables has a lower AIC, BIC than the model with original data, the visualizations between them are visually similar. This indicates that adding two external variables is not helpful for changing the forecast trajectory. However, this is helpful for improving the statistical goodness of fitness. There are some outliers in Normal Q-Q Plot and uncertainty increases in forecasting from the SARIMA Model 2 with original data. In short-term, this model is the most suitable but in long-term, using the model 2's forecasting causes less precise after next 1 year ahead because confidence intervals gradually widen over time. Overall, our project concludes that the Model 2, SARIMA(1,1,1)(0,1,1)[5] is the most appropriate model for forecasting seasonal demand. But, if we have more data with external variables, such as, promotions and holidays, it might be helped in precision for a long-term. Thank you!

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When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.