

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

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```
## 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
## 2    1
## 3    2
## 4    3
## 5    4
## 6    5
## 7    6
## 8    7
## 9    8
## 10   9
## 11  10
## 12  11
## 13  12
## 14  13
## 15  14
## 16  15
## 17  16
## 18  17
## 19  18
## 20  19
## 21  20
## 22  21
## 23  22
## 24  23
## 25  24
## 26  25
## 27  26
## 28  27
## 29  28
## 30  29
## 31  30
```

## 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)
```

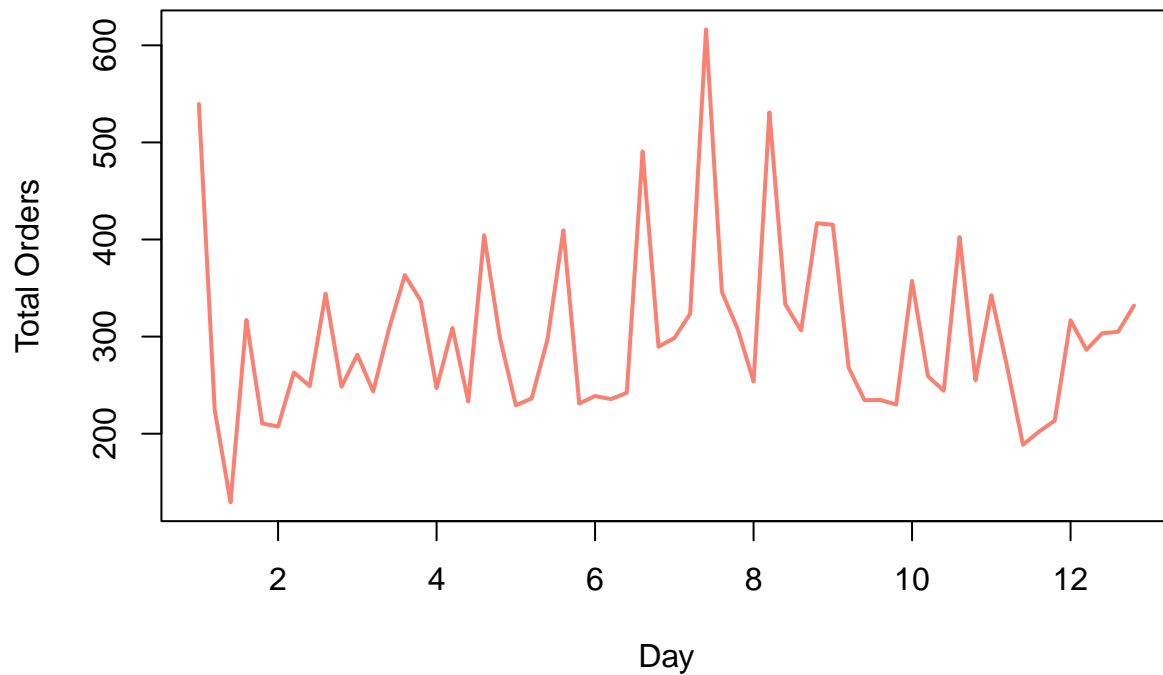
```
## Frequency = 5
```

```
## [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")
```


Time Series Plot – Realization vs Time



```
## 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
```

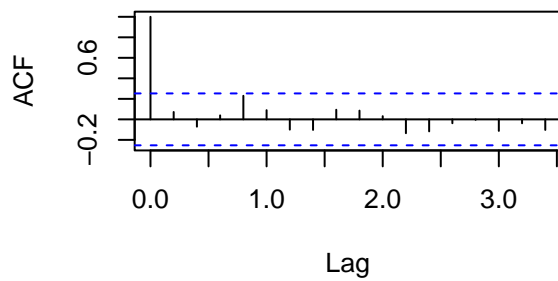
```
log_miles2_ts <- log(miles2_ts)
```

```
# ACF & PACF plots of log-transformed data
```

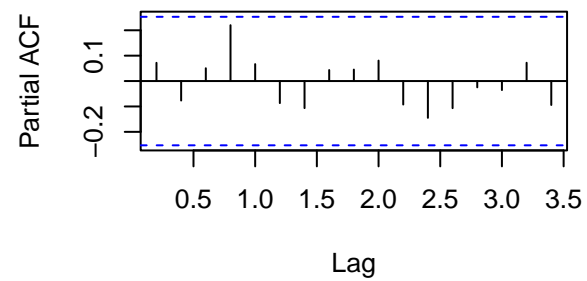
```
acf(log(miles2_ts), main="ACF: Log-Transformed Data")
```

```
pacf(log(miles2_ts), main="PACF: Log-Transformed Data") # No need for transformation.
```

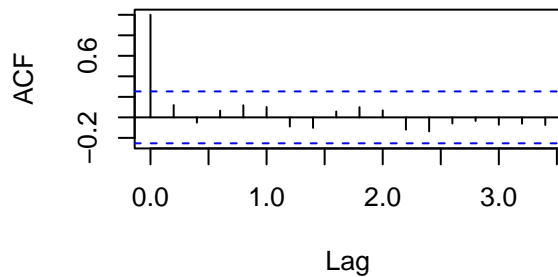
ACF: Original Data



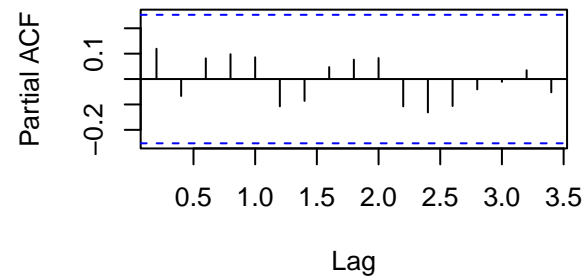
PACF: Original Data



ACF: Log-Transformed Data



PACF: Log-Transformed Data



```
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
```

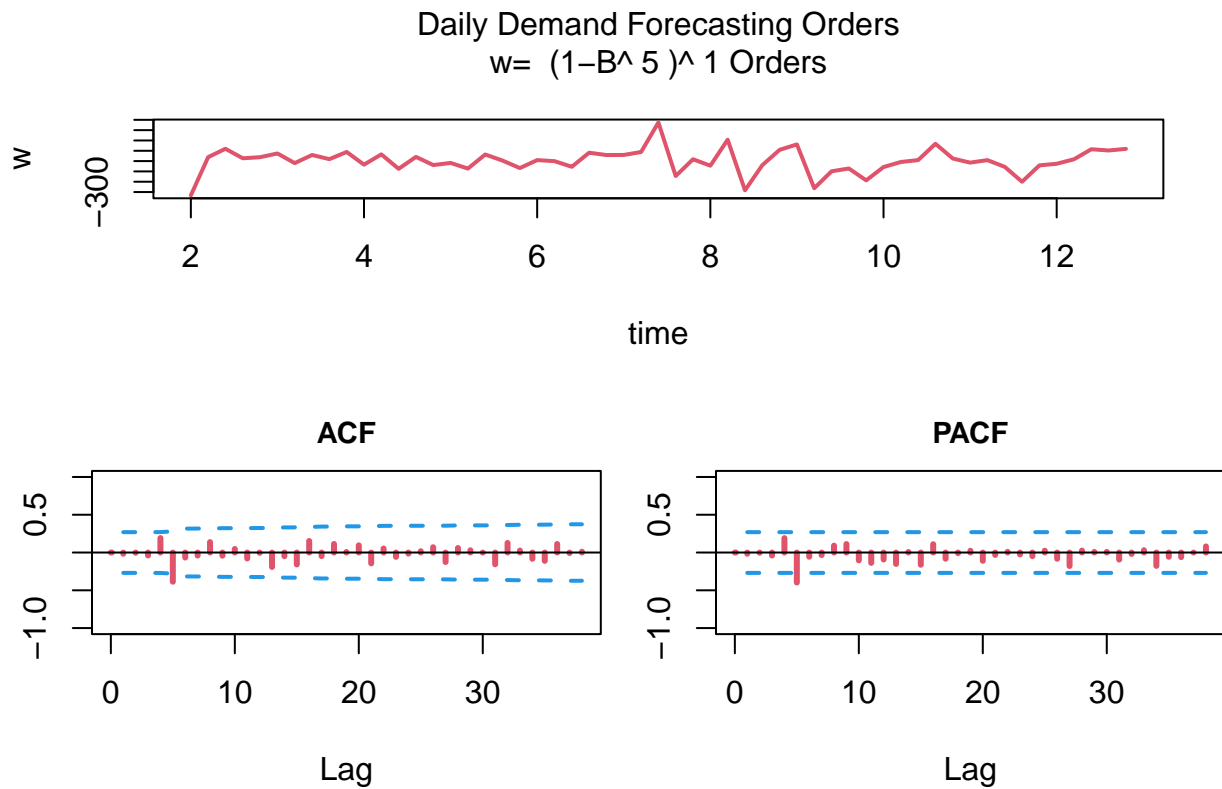
```
## Time Series:
## Start = c(1, 1)
## End = c(12, 5)
## Frequency = 5
## [1] 539.577 224.675 129.412 317.120 210.517 207.364 263.043 248.958 344.291
## [10] 248.428 281.420 243.568 308.178 363.402 336.872 246.992 308.880 233.126
## [19] 404.380 298.560 229.249 236.304 297.174 409.401 231.035 238.826 235.598
## [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
```



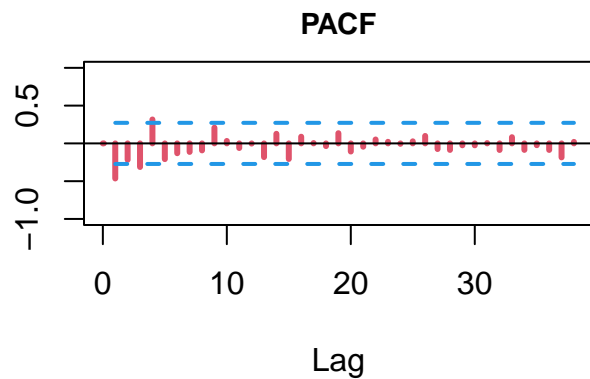
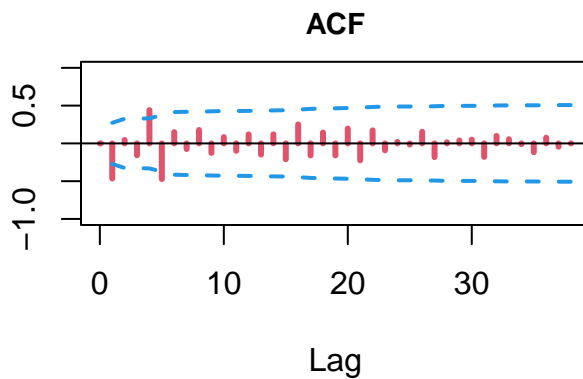
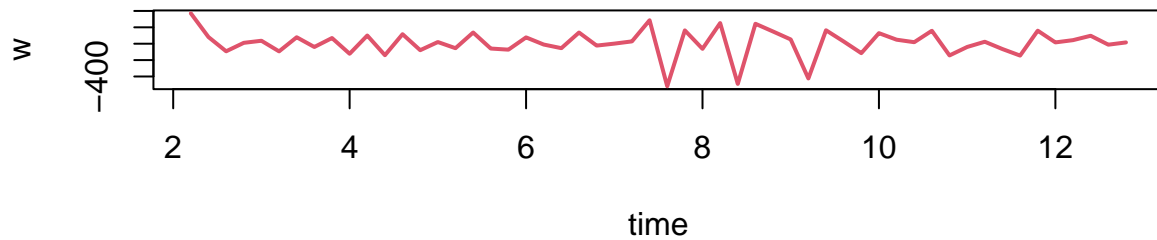
```
iden(miles2_tsd, d = 1, D = 1) # First order and seasonal but it would be over-differencing.
```

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

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

Daily Demand Forecasting Orders

$w = (1-B)^1 (1-B^5)^1$ Orders



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 significance 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
## 2    1
## 3    2
## 4    3
## 5    4
## 6    5
## 7    6
## 8    7
## 9    8
## 10   9
## 11  10
## 12  11
## 13  12
## 14  13
## 15  14
## 16  15
## 17  16
## 18  17
```

## 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 p-value)
```

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

```
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
```

```
# 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
```

```
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
```

```
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.

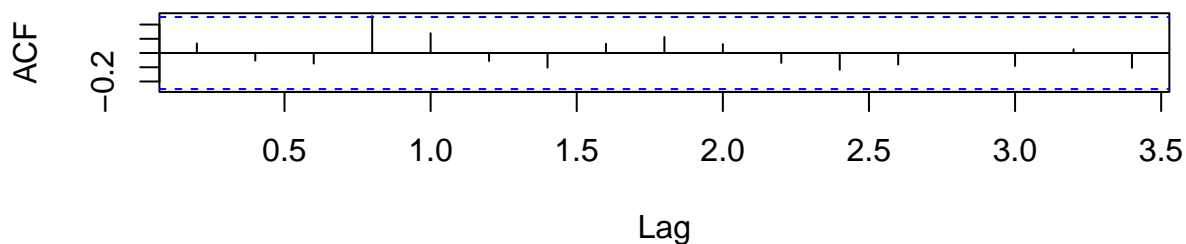
Model 4 has the highest AIC and BIC values and in the Normal Q-Q plot, it looks more skewed.

```
# 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))

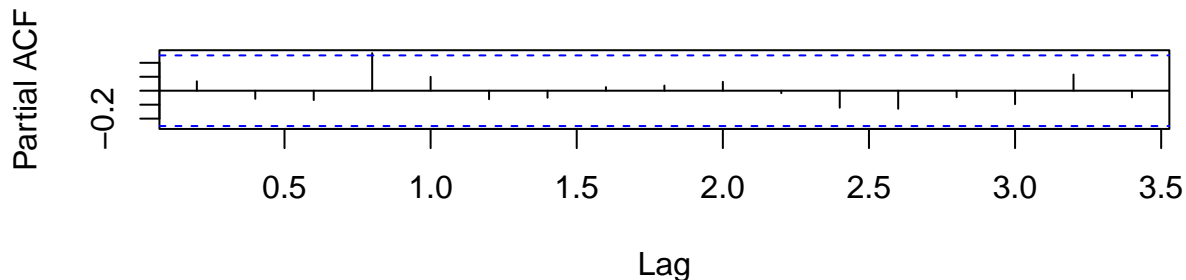
# Box.test(residuals(fit4), lag = 10, type = "Ljung-Box", fitdf = 3) # df = 3.
# qqnorm(residuals(fit4)); qqline(residuals(fit4), col = "blue")

# 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)")
```

ACF of Residuals(fit2)



PACF of Residuals(fit2)



```

par(mfrow = c(1, 1))

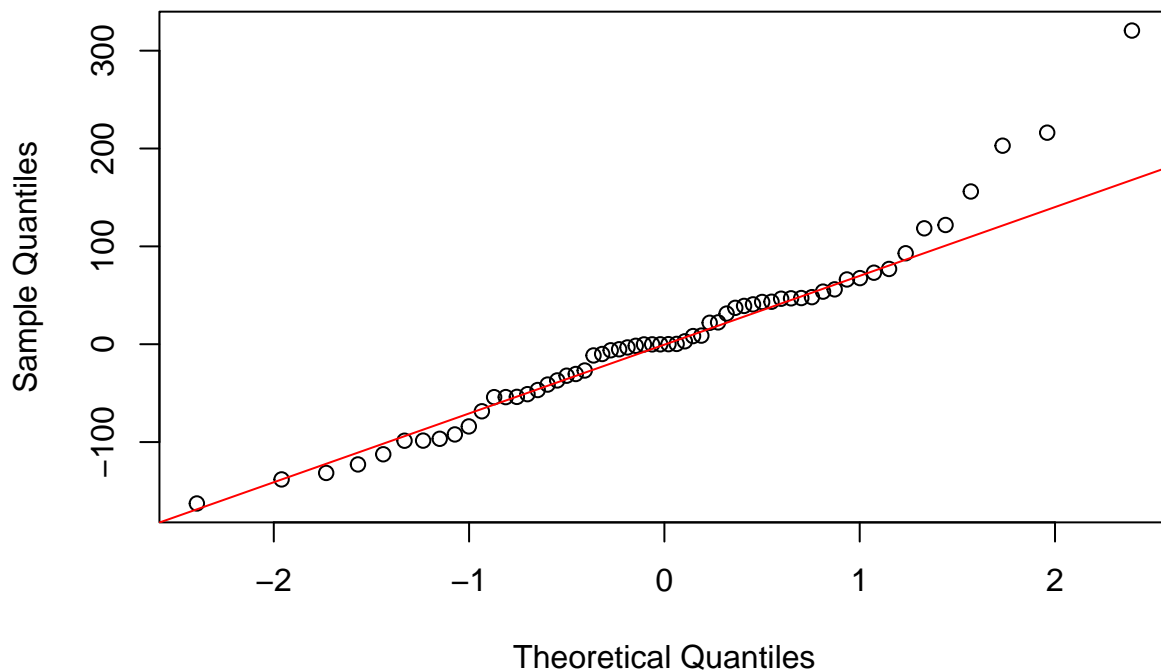
Box.test(residuals(fit2), lag = 10, type = "Ljung-Box", fitdf = 3)

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

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

```

Normal Q-Q Plot



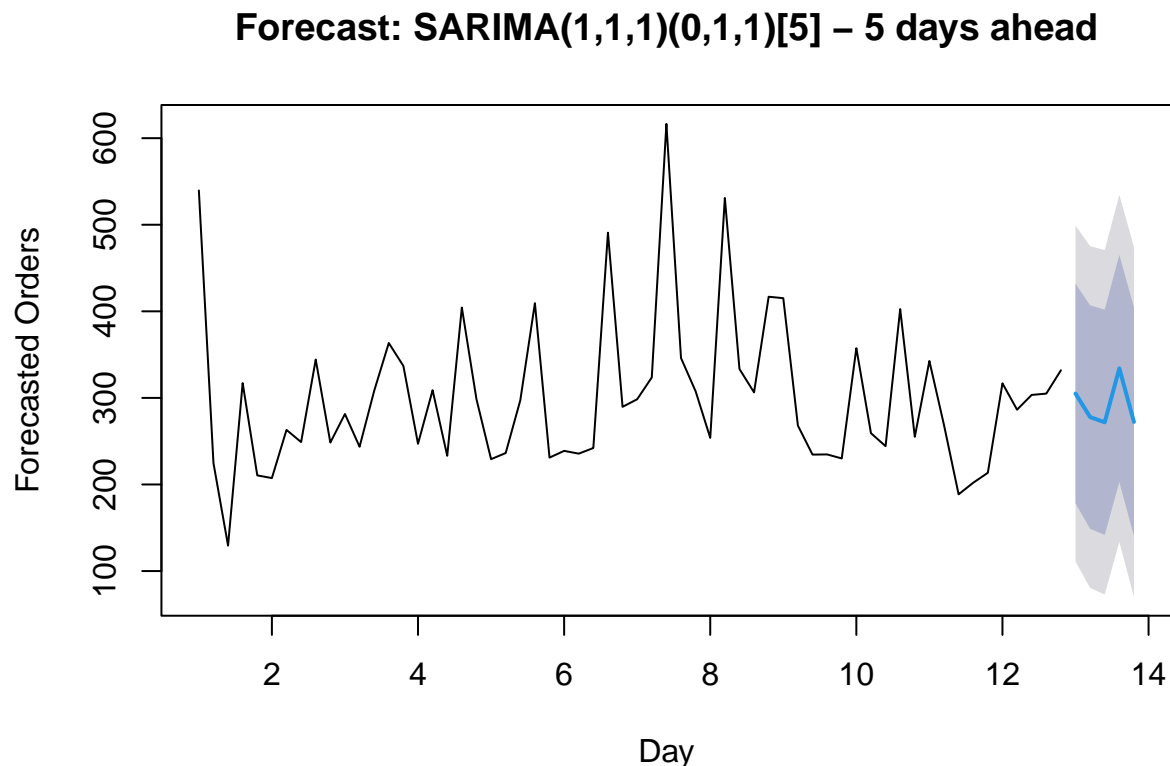
8. Forecasting with Model 2 (SARIMA(1,1,1)(0,1,1)[5])

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.

```
#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", ylab = "Forecasted Orders")
```

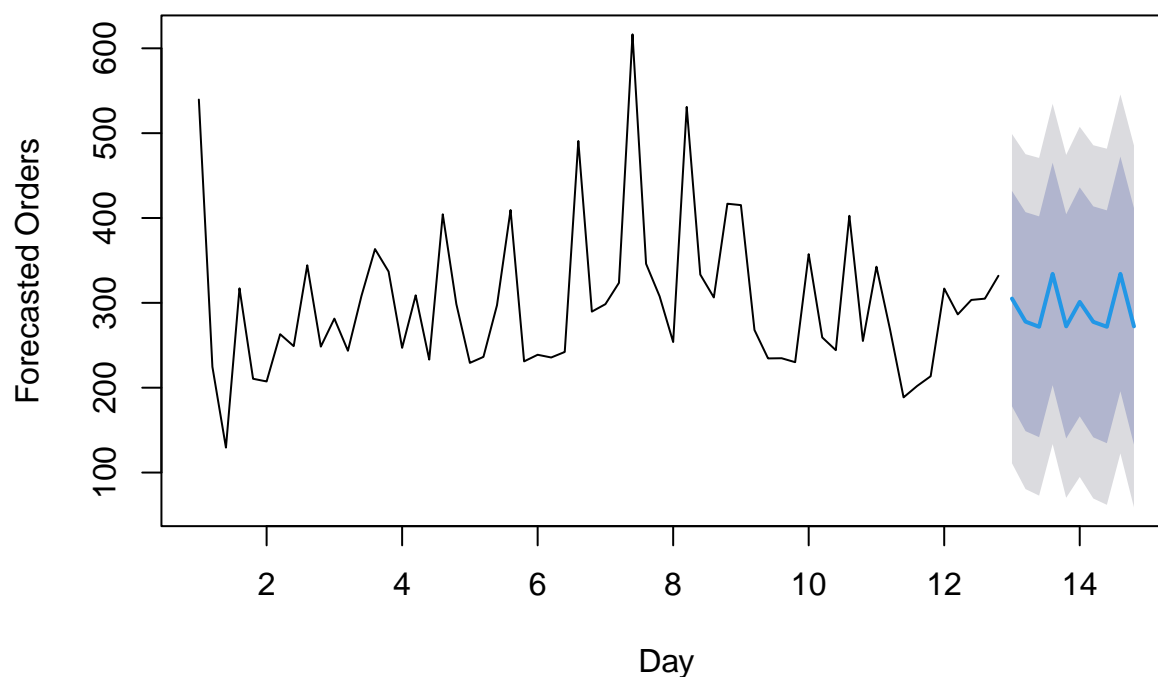


```
print(forecast_result_fit2)
```

##	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

```
#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", ylab = "Forecasted Orders")
```


Forecast: SARIMA(1,1,1)(0,1,1)[5] – 10 days ahead



```
print(forecast_result_fit2)
```

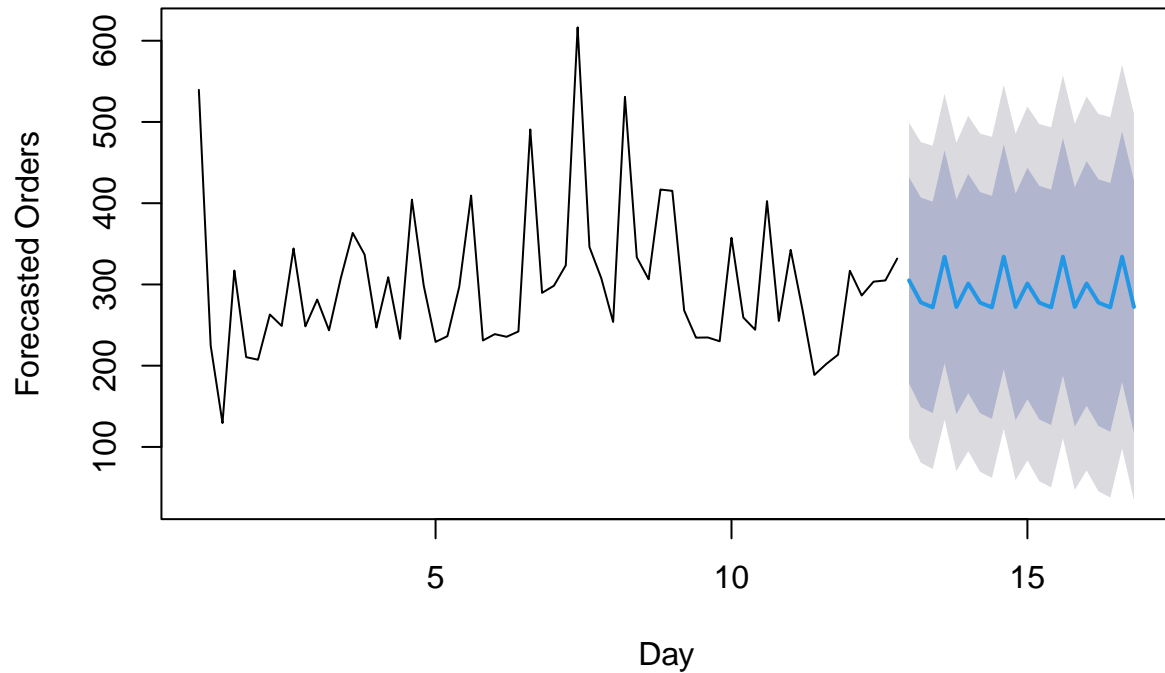
```
##      Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## 13.00      305.0187 178.1410 431.8963 110.97607 499.0613
## 13.20      277.8528 148.8138 406.8917  80.50472 475.2008
## 13.40      271.8225 141.7189 401.9262  72.84621 470.7989
## 13.60      334.0946 202.9906 465.1986 133.58834 534.6008
## 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", ylab = "Forecasted Orders")
```

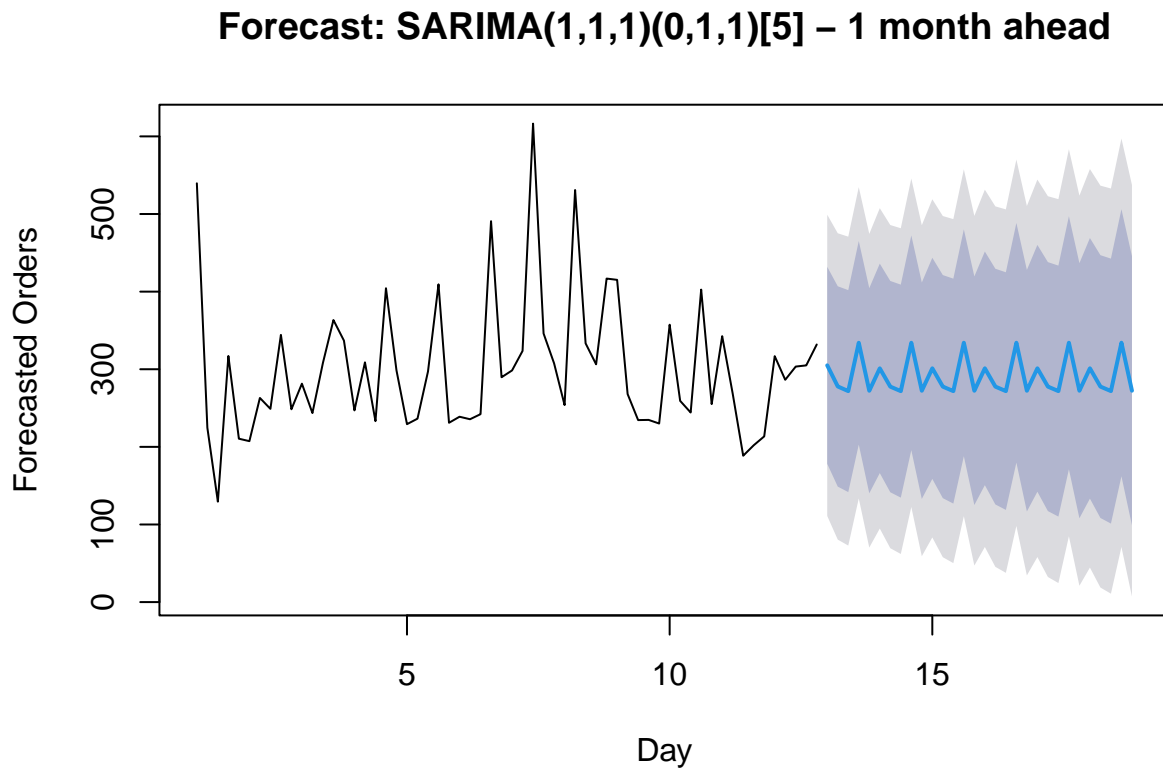
Forecast: SARIMA(1,1,1)(0,1,1)[5] – 20 days ahead



```
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

```
#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", ylab = "Forecasted Orders")
```



```
print(forecast_result_fit2)
```

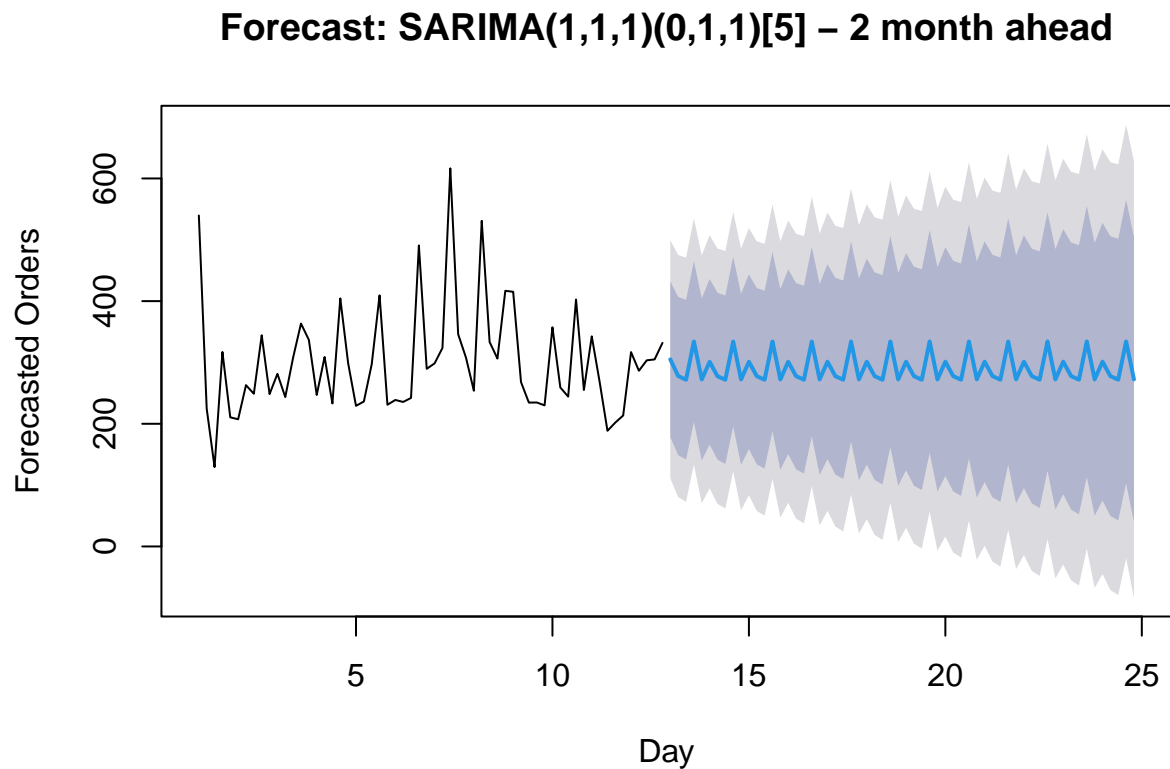
##	Point	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
## 13.00	305.0187	178.14104	431.8963	110.976071	499.0613	
## 13.20	277.8528	148.81382	406.8917	80.504723	475.2008	
## 13.40	271.8225	141.71891	401.9262	72.846209	470.7989	
## 13.60	334.0946	202.99060	465.1986	133.588344	534.6008	
## 13.80	272.3029	140.18989	404.4159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

```
#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", ylab = "Forecasted Orders")
```



```
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
```

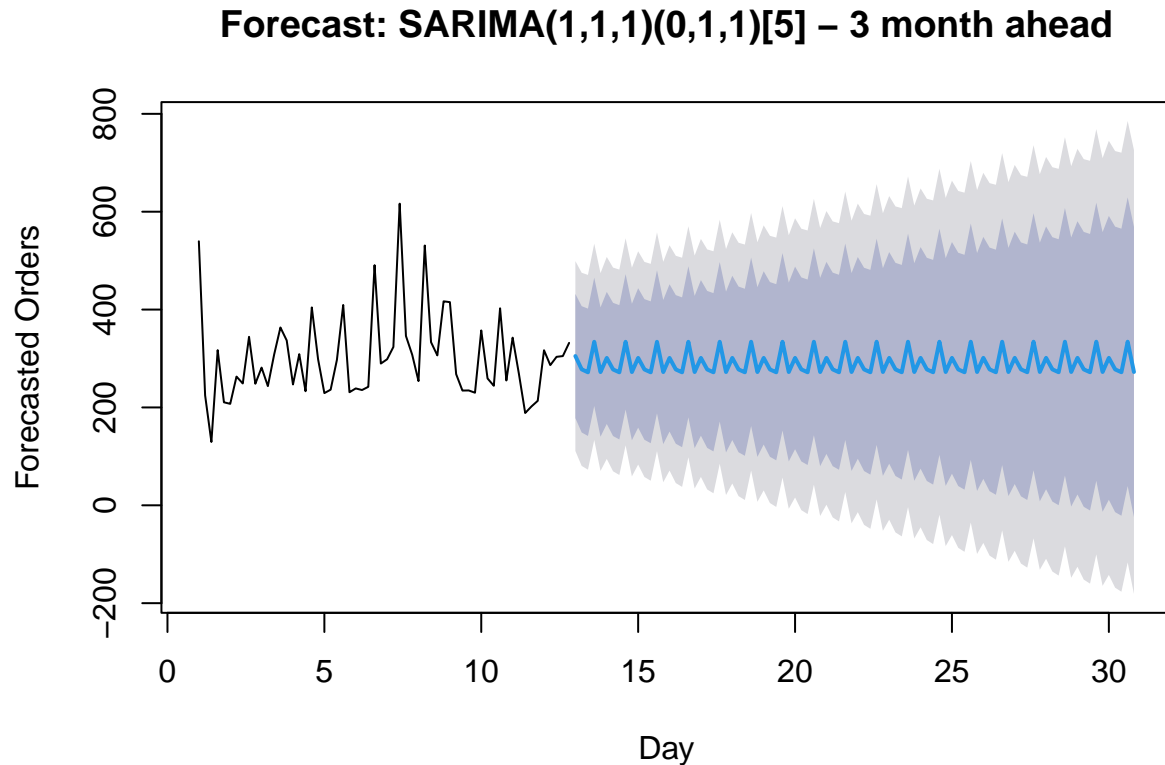
## 14.00	301.1508	166.23229	436.0692	94.810775	507.4907
## 14.20	277.6110	141.50917	413.7128	69.461225	485.7607
## 14.40	271.8167	134.61266	409.0207	61.981236	481.6522
## 14.60	334.1041	195.80944	472.3988	122.600666	545.6075
## 14.80	272.3134	132.91177	411.7150	59.117004	485.5098
## 15.00	301.1613	158.72195	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", ylab = "Forecasted Orders")
```



```
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

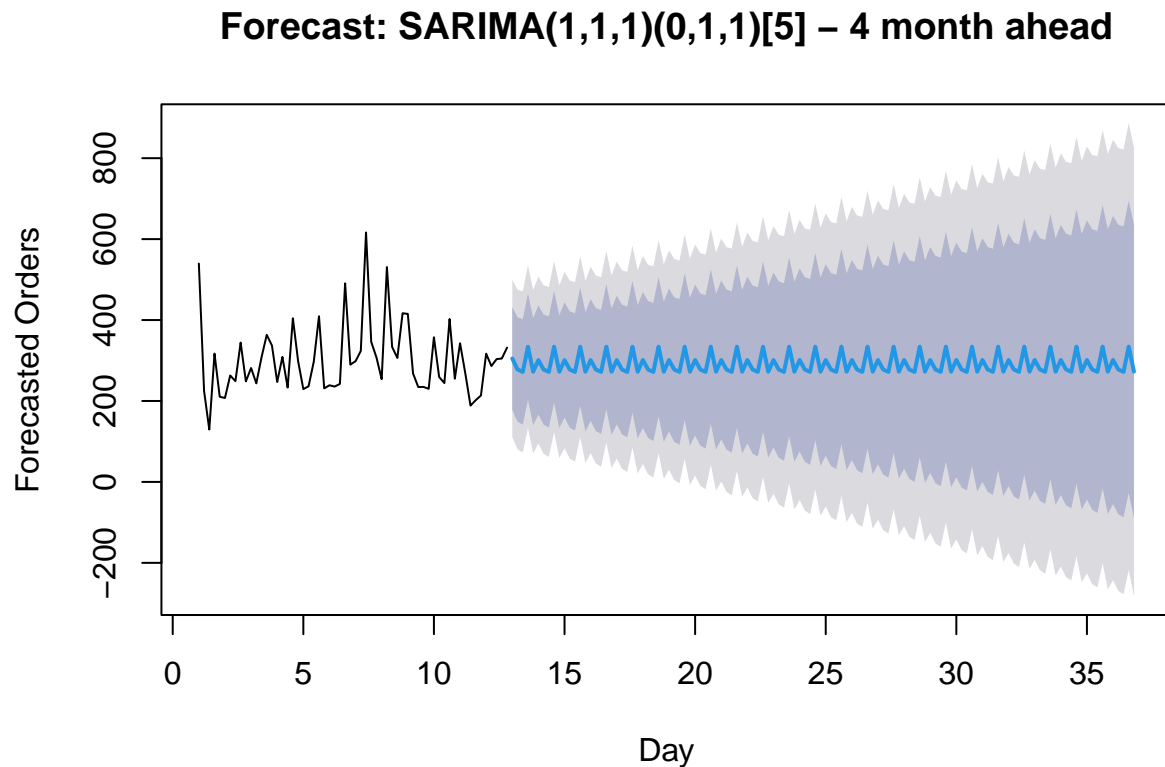
## 16.20	277.6321	125.8085029	429.4558	45.437928	509.8263
## 16.40	271.8378	118.7630713	424.9126	37.730184	505.9455
## 16.60	334.1252	179.8119910	488.4385	98.123491	570.1270
## 16.80	272.3345	116.7590646	427.9100	34.402382	510.2667
## 17.00	301.1825	142.2047043	460.1602	58.046961	544.3180
## 17.20	277.6427	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
```

```
#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", ylab = "Forecasted Orders")
```




```
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

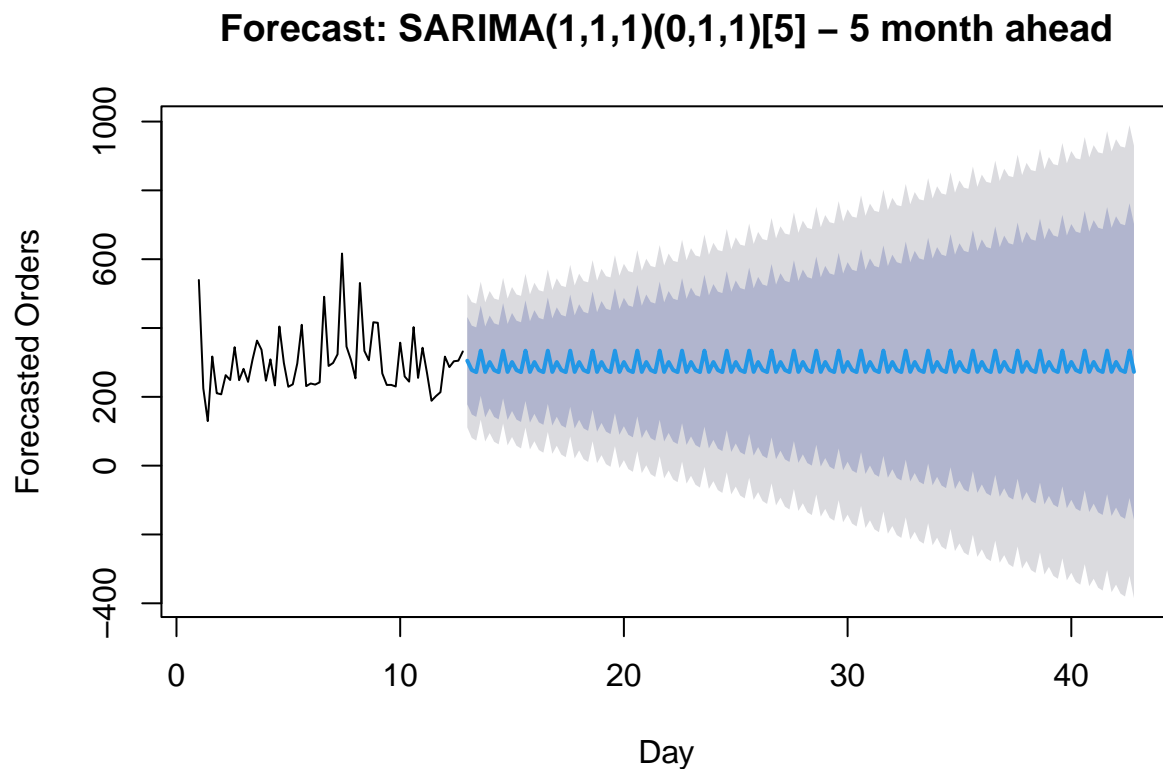
## 23.00	301.2459	85.0684086	517.4234	-29.369045	631.8609
## 23.20	277.7061	59.9211784	495.4911	-55.367218	610.7795
## 23.40	271.9119	52.6116935	491.2120	-63.478798	607.3025
## 23.60	334.1993	113.3960565	555.0024	-3.490095	671.8886
## 23.80	272.4086	50.0612533	494.7559	-67.642297	612.4594
## 24.00	301.2565	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", ylab = "Forecasted Orders")
```



```
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

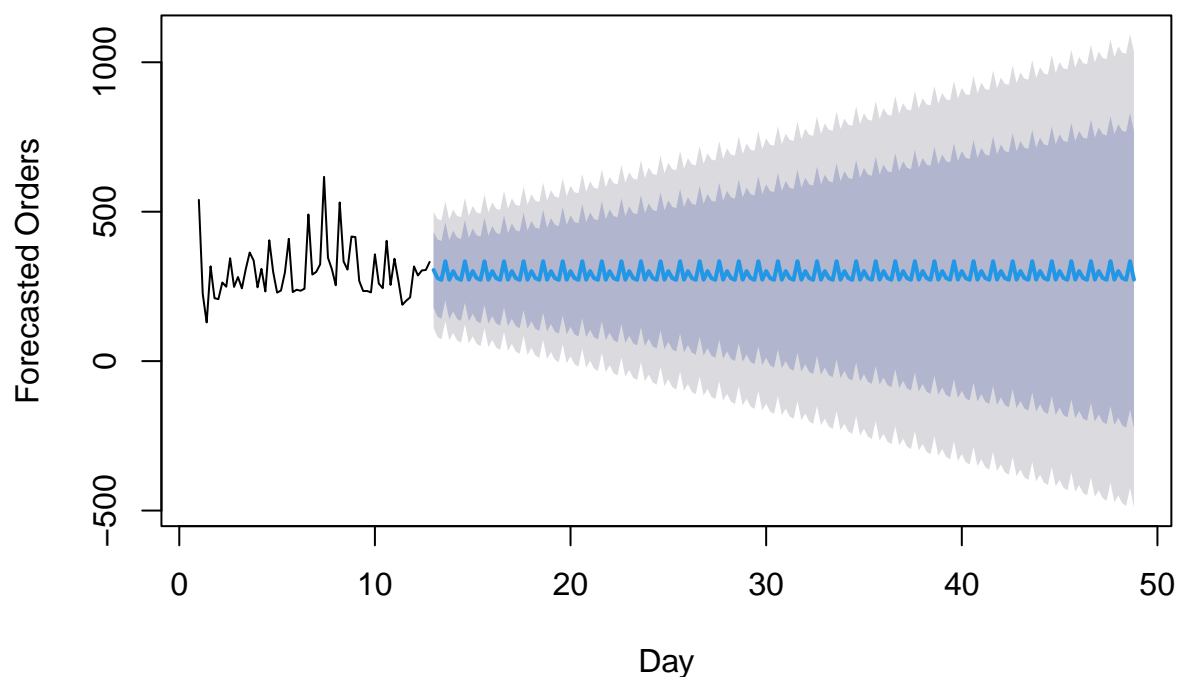
## 24.00	301.2565	74.8549291	527.6580	-44.994811	647.5078
## 24.20	277.7167	49.6879537	505.7455	-71.023182	626.4566
## 24.40	271.9224	42.3587102	501.4861	-79.164980	623.0098
## 24.60	334.2098	103.1230345	565.2966	-19.206924	687.6266
## 24.80	272.4191	39.7664886	505.0718	-83.392378	628.2306
## 25.00	301.2671	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", ylab = "Forecast")
```

Forecast: SARIMA(1,1,1)(0,1,1)[5] – 6 month ahead



```
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

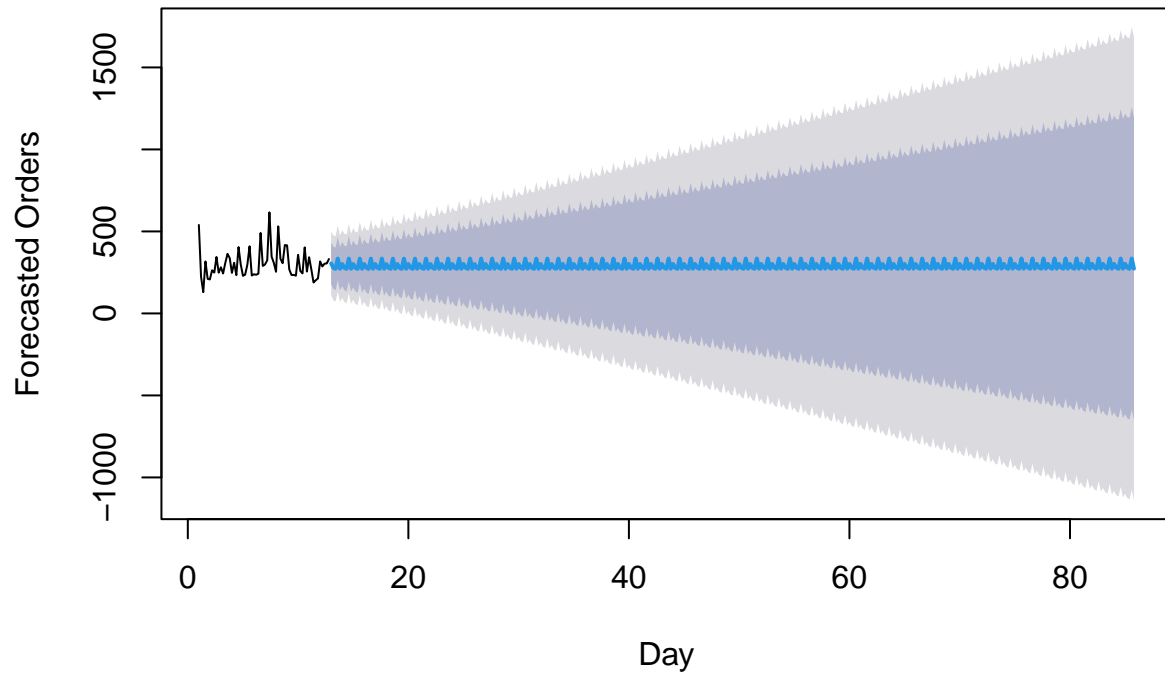
## 39.00	301.4151	-88.0095458	690.8397	-294.158487	896.9886
## 39.20	277.8753	-113.3012518	669.0519	-320.377617	876.1282
## 39.40	272.0810	-120.7588921	664.9209	-328.715781	872.8778
## 39.60	334.3684	-60.1268423	728.8637	-268.960021	937.6969
## 39.80	272.5777	-123.6302712	668.7857	-333.370113	878.5256
## 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 = "Forecast")
```

Forecast: SARIMA(1,1,1)(0,1,1)[5] – 1 year ahead



```
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
## 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

## 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

## 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
## 61.40	272.3136	-370.8558971	915.4832	-711.329278	1255.9565
## 61.60	334.6010	-310.2655184	979.4676	-651.637249	1320.8393
## 61.80	272.8103	-373.8181287	919.4388	-716.122558	1261.7432
## 62.00	301.6583	-349.5056762	952.8222	-694.211040	1297.5276
## 62.20	278.1185	-374.8326118	931.0696	-720.484048	1276.7210
## 62.40	272.3242	-382.3298006	926.9782	-728.882696	1273.5311
## 62.60	334.6116	-321.7402867	990.9635	-669.191990	1338.4152
## 62.80	272.8209	-385.2939624	930.9358	-733.678928	1279.3207
## 63.00	301.6688	-360.9836434	964.3213	-711.770673	1315.1083
## 63.20	278.1291	-386.3111888	942.5693	-738.044614	1294.3027
## 63.40	272.3348	-393.8091166	938.4787	-746.444392	1291.1139
## 63.60	334.6222	-333.2204240	1002.4648	-686.754942	1355.9993
## 63.80	272.8315	-396.7751143	942.4381	-751.243431	1296.9064
## 64.00	301.6794	-372.4668203	975.8256	-729.338273	1332.6971
## 64.20	278.1396	-397.7949410	954.0742	-755.613094	1311.8924
## 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.

```
# 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
```

```
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
```

```
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.
```

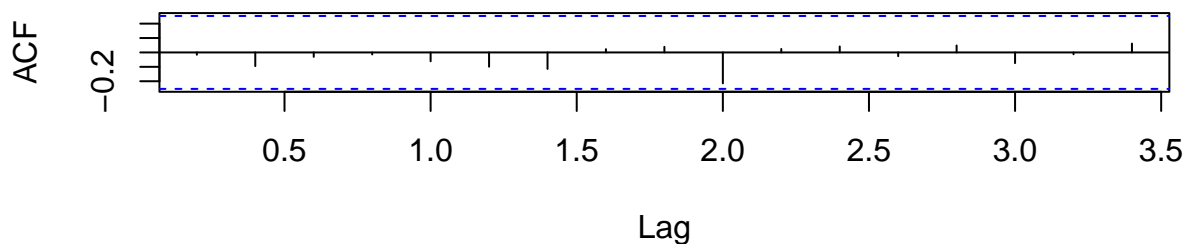
```
## Series: ts_data
## Regression with ARIMA(1,1,1)(0,1,1)[5] errors
##
## Coefficients:
##          ar1      ma1      sma1  urgent_ts  nonurgent_ts
##      -0.0013  -1.000  -0.9999    1.0068    0.9652
## s.e.   0.1368   0.099   0.4106    0.1355    0.0531
##
## sigma^2 = 568.4: log likelihood = -254.76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

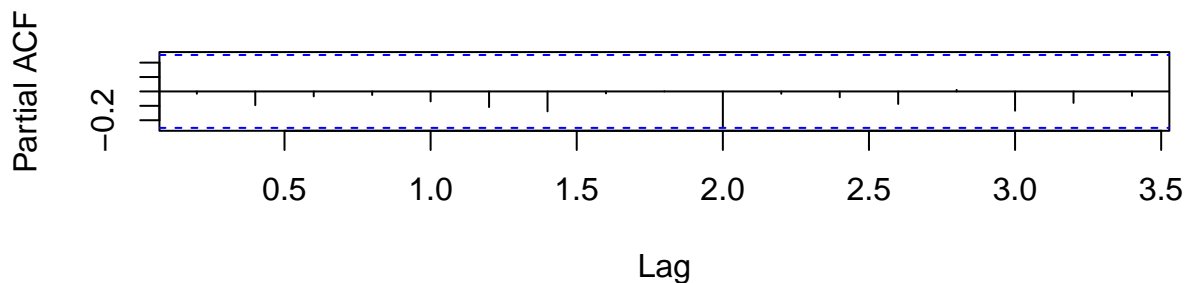
```
# Check process for residual diagnostics.
```

```
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
```

ACF of Residuals (Regression SARIMA 2)



PACF of Residuals (Regression SARIMA 2)



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

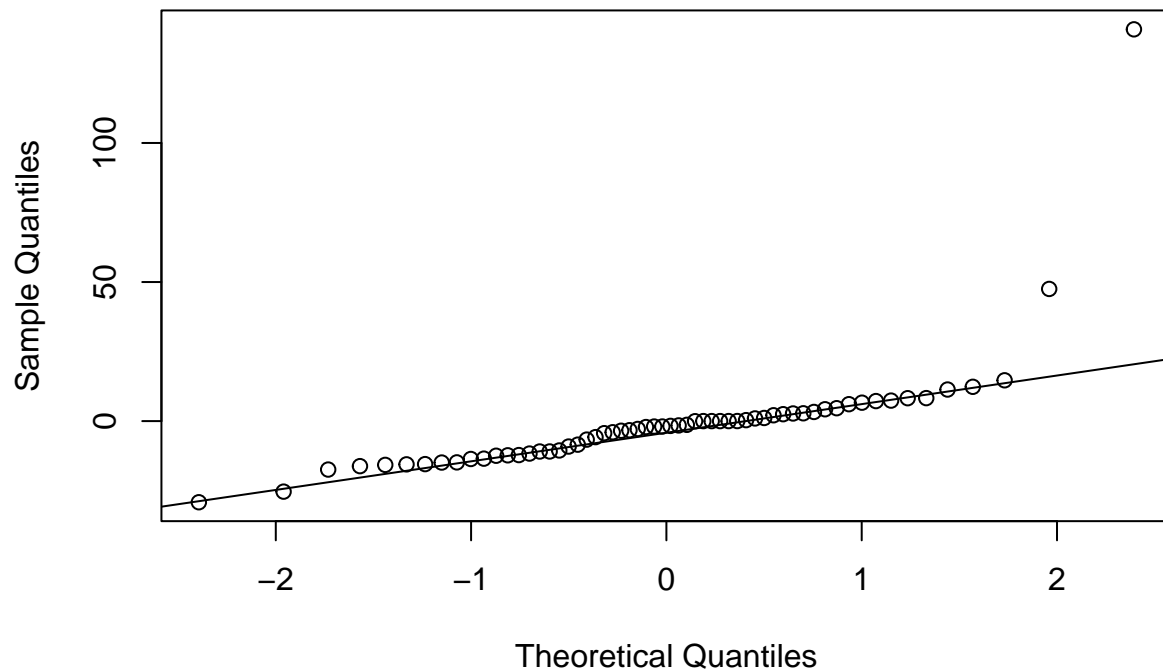
Box.test(residuals(fit_regression_sarima2), lag = 10, type = "Ljung-Box") # Higher P-value than signifi
```

```
##
## 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")
```

Normal Q-Q Plot



```
# 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)
```

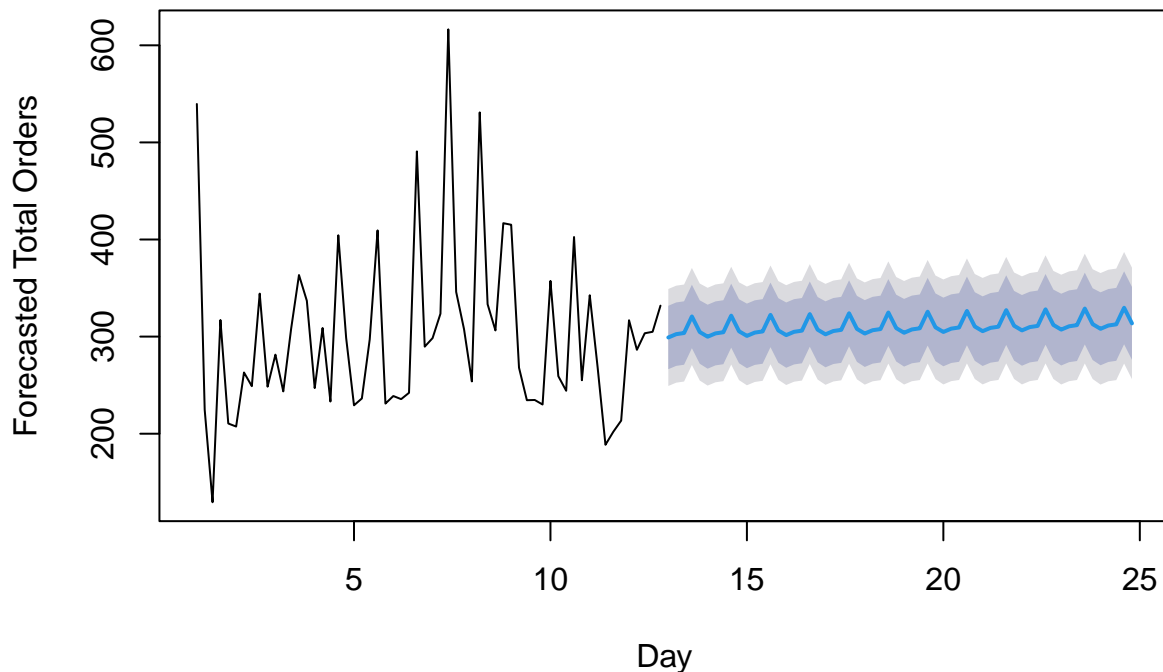
```
forecast_regression_sarima2 <- forecast(fit_regression_sarima2,  
                                       h = 60,  
                                       xreg = future_xreg,  
                                       level = c(80,95))
```

```
## 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 Model12 Forecast for the next 60 Days",  
     xlab = "Day", ylab = "Forecasted Total Orders")
```

Regression SARIMA Model2 Forecast for the next 60 Days



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 statistically 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!

R Markdown

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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.