Retail and Food services Sales Time Series Analysis + Forecasting

Arinze Francis

2022-06-20

```
## function (..., list = character(), pos = -1, envir = as.environment(pos),
##     inherits = FALSE)
## {
##     dots <- match.call(expand.dots = FALSE)$...
##     if (length(dots) && !all(vapply(dots, function(x) is.symbol(x) ||
##         is.character(x), NA, USE.NAMES = FALSE)))
##         stop("... must contain names or character strings")
##     names <- vapply(dots, as.character, "")
##     if (length(names) == 0L)
##         names <- character()
##     list <- .Primitive("c")(list, names)
##     .Internal(remove(list, envir, inherits))
## }
## <bytecode: 0x0000000014f51598>
## <environment: namespace:base>
```

Load R packages

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

```
## Warning: package 'ggplot2' was built under R version 4.1.2
```

```
## Warning: package 'fpp2' was built under R version 4.1.3
```

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

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

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

Dataset loading

```
## # A tibble: 310 x 3
##     Year Month  Sales
##    <dbl> <chr>  <dbl>
##  1  1992 Jan   164083
##  2  1992 Feb   164260
##  3  1992 Mar   163747
##  4  1992 Apr   164759
##  5  1992 May   165617
##  6  1992 Jun   166098
##  7  1992 Jul   167305
##  8  1992 Aug   167797
##  9  1992 Sep   169407
## 10  1992 Oct   170681
## # ... with 300 more rows
```

```
## [1] FALSE
```

```
## # A tibble: 310 x 2
##     Year  Sales
##    <dbl>  <dbl>
##  1  1992 164083
##  2  1992 164260
##  3  1992 163747
##  4  1992 164759
##  5  1992 165617
##  6  1992 166098
##  7  1992 167305
##  8  1992 167797
##  9  1992 169407
## 10  1992 170681
## # ... with 300 more rows
```

Retail sales and year
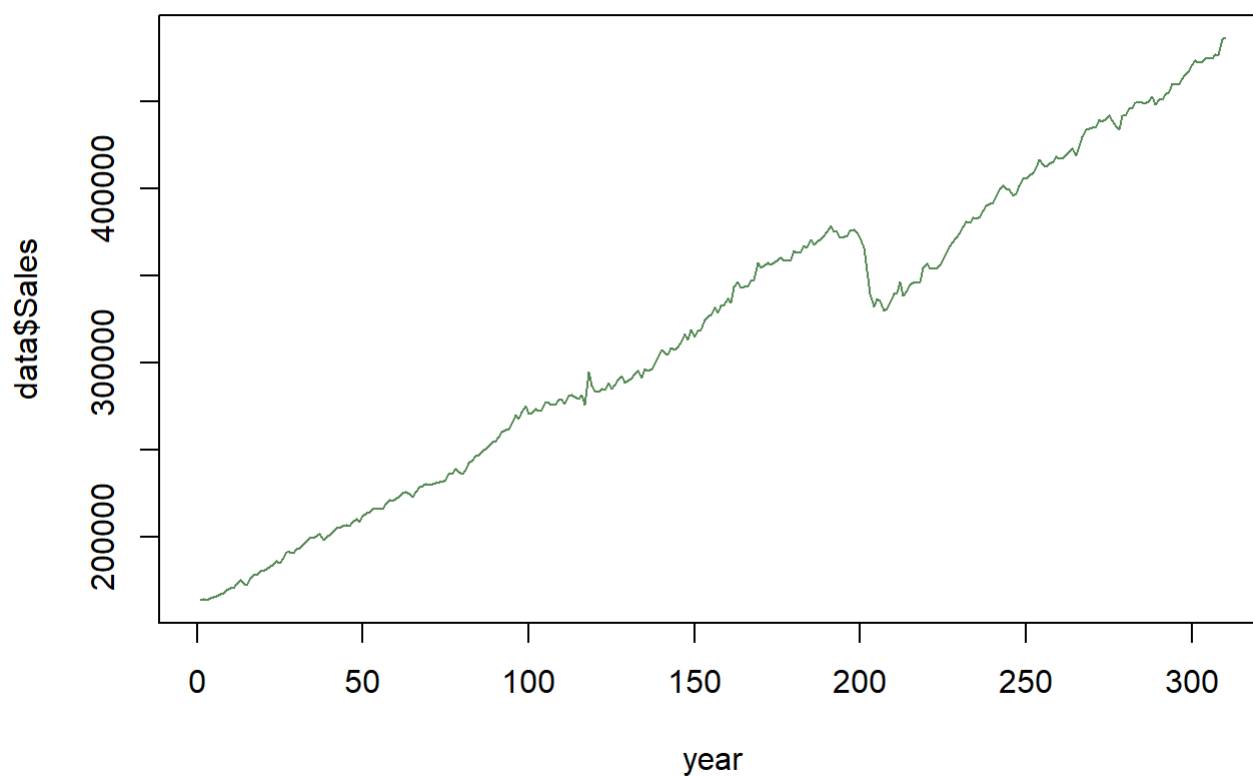
Converting to time series class and plotting the time series data

```
data_ts <- ts(data$Sales, start=c(1992,1), frequency = 12)
data_ts
```

```
##          Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1992 164083 164260 163747 164759 165617 166098 167305 167797 169407 170681
## 1993 175078 173770 172328 176766 178445 178201 180759 180692 181800 182910
## 1994 185128 188077 191588 191632 190940 193196 193763 196157 197754 199579
## 1995 201583 198383 200230 201048 202993 205507 204959 206529 206978 206157
## 1996 208731 212011 213855 214644 216304 216059 216374 216355 219240 221039
## 1997 223524 225409 226136 224588 222906 226048 228738 229317 230284 229822
## 1998 231605 231664 233043 235976 237055 238958 237423 236412 238542 242531
## 1999 246891 249510 250657 252418 254738 255472 257441 260253 261352 261825
## 2000 268091 272020 275214 271004 271418 273440 272638 272943 277523 276973
## 2001 278916 278799 276468 280804 281540 280399 279522 281423 276095 294613
## 2002 283577 285061 284263 288820 284994 287401 290427 292582 288434 289634
## 2003 295294 291178 296347 295643 296395 299662 302788 307745 305916 304824
## 2004 309225 311427 316935 313531 318962 314971 318532 318945 324607 326680
## 2005 328957 332980 333293 337003 334454 343955 346690 343110 343633 344319
## 2006 357360 354735 355826 357601 356524 357754 359087 360514 358702 358398
## 2007 363520 364090 367414 366280 370867 368080 369500 371019 372936 375217
## 2008 375280 371734 372656 373086 375851 376378 374837 372112 366377 352768
## 2009 336918 335698 329947 331313 334315 339535 340229 346657 338427 341578
## 2010 346252 346835 354564 357095 354267 353811 354457 356505 359326 363736
## 2011 372047 374970 378472 380796 380402 383072 382930 383822 387402 390299
## 2012 395317 400042 401859 400077 399370 395782 397347 401904 405658 405877
## 2013 412125 416603 413848 412655 414182 415777 418222 417503 417565 419693
## 2014 418800 424117 429720 433675 434334 435094 435688 439554 438687 440396
## 2015 435929 434153 442225 442183 446238 446238 449403 449592 449496 448616
## 2016 448171 451209 451274 454231 455753 460563 459744 460198 463045 465368
## 2017 473464 472513 472991 474547 474760 474488 476752 476513 485419 486553
##          Nov    Dec
## 1992 171025 172995
## 1993 184746 186339
## 1994 199723 200670
## 1995 208661 210434
## 1996 220989 221898
## 1997 230486 231197
## 1998 244307 246577
## 1999 264883 269876
## 2000 275923 275736
## 2001 286960 283708
## 2002 291475 293819
## 2003 308551 307362
## 2004 327837 331877
## 2005 347239 347526
## 2006 359208 364270
## 2007 378481 375256
## 2008 339776 332307
## 2009 344579 346215
## 2010 367330 369294
## 2011 391571 391744
## 2012 407386 409343
## 2013 421033 423005
## 2014 442106 439323
## 2015 450509 452756
```
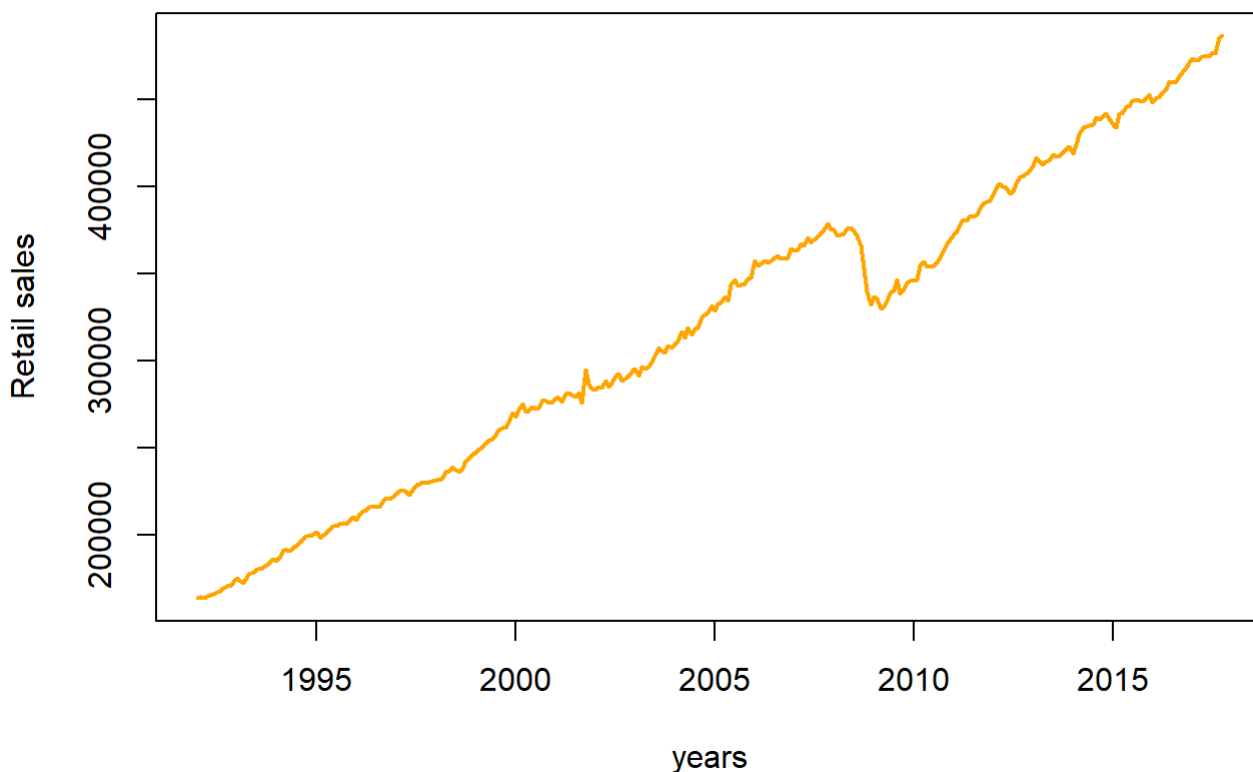
```
## 2016 466974 470996
## 2017
```

```
class(data_ts)
```

```
## [1] "ts"
```

```
# Plotting time series dataset
plot(data_ts, xlab="years", ylab="Retail sales", main="Retail and Food service sales vs Years",c
ol="orange",type = "l", lwd=2)
```

Retail and Food service sales vs Years


```
# Observation of the plot:
# 1. Values of the data are stored in correct order and no missing data.
# 2. There is an upward trend. On the average, Retail and Food service sales is going up. Sales
 are increasing in numbers, implying presence of trend component.
# 3. there was a noticeable fall in retail and food sales in 2008 due to the economic crisis of
 2008.
# 4. After the crisis, the sales returned to its increasing rise.
# 5. presence of a seasonality
```

to get the seasonality better

```
ggseasonplot(data_ts, year.labels = T, year.labels.left = T) +ylab("degree") +ggtitle("Seasonal
  Plot Retail and service food sales Data")
```


Seasonal Plot Retail and service food sales Data
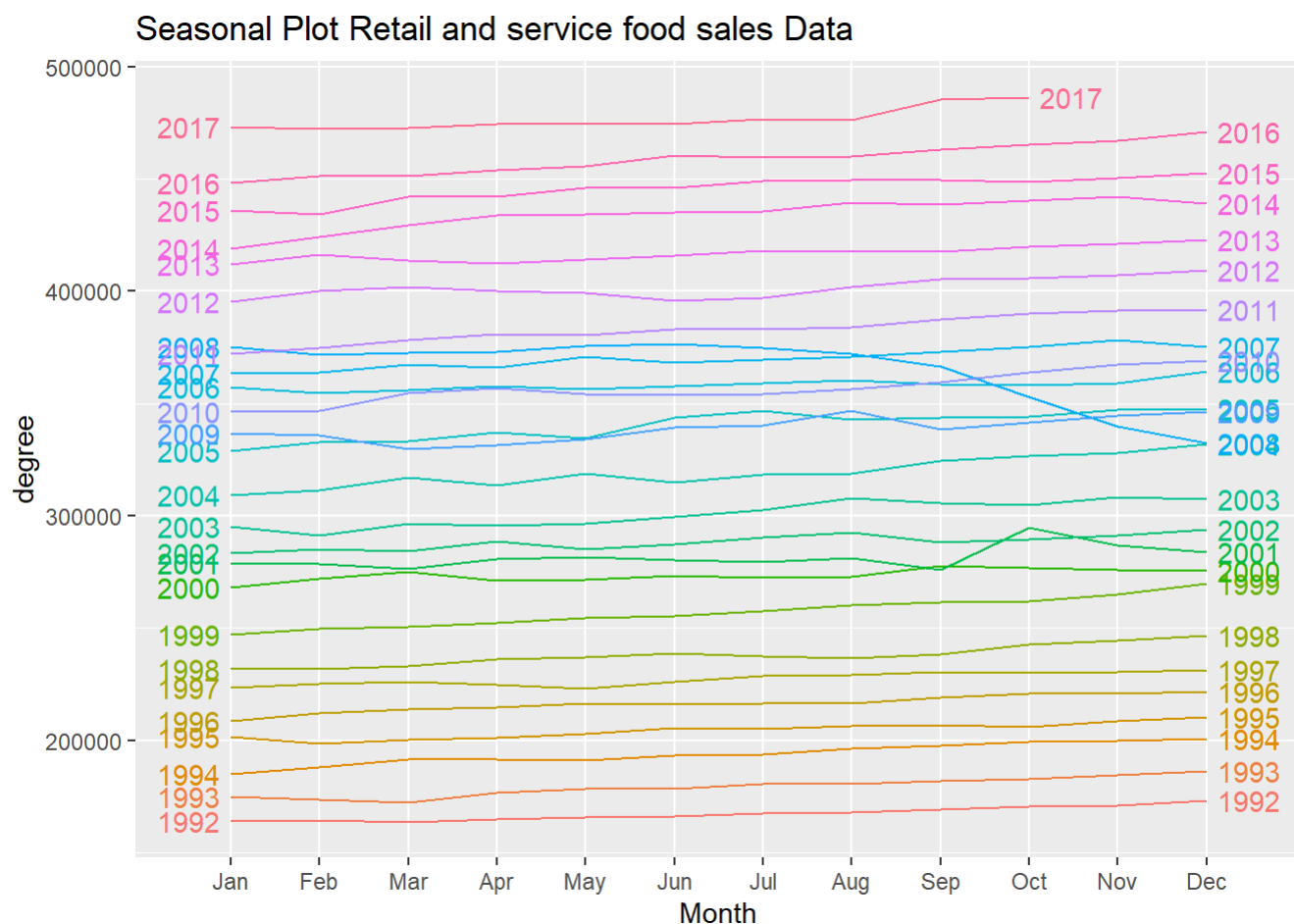
```
# Observation:
# 1) as the year goes by, sales increases - indicating trend.
# 2) There was a huge fall in August 2008.

ggseasonplot(data_ts, polar = T) +ylab("degree") +ggtitle("Polar plot: Seasonal Plot Retail and
  service food sales Data")
```

Polar plot: Seasonal Plot Retail and service food sales Data
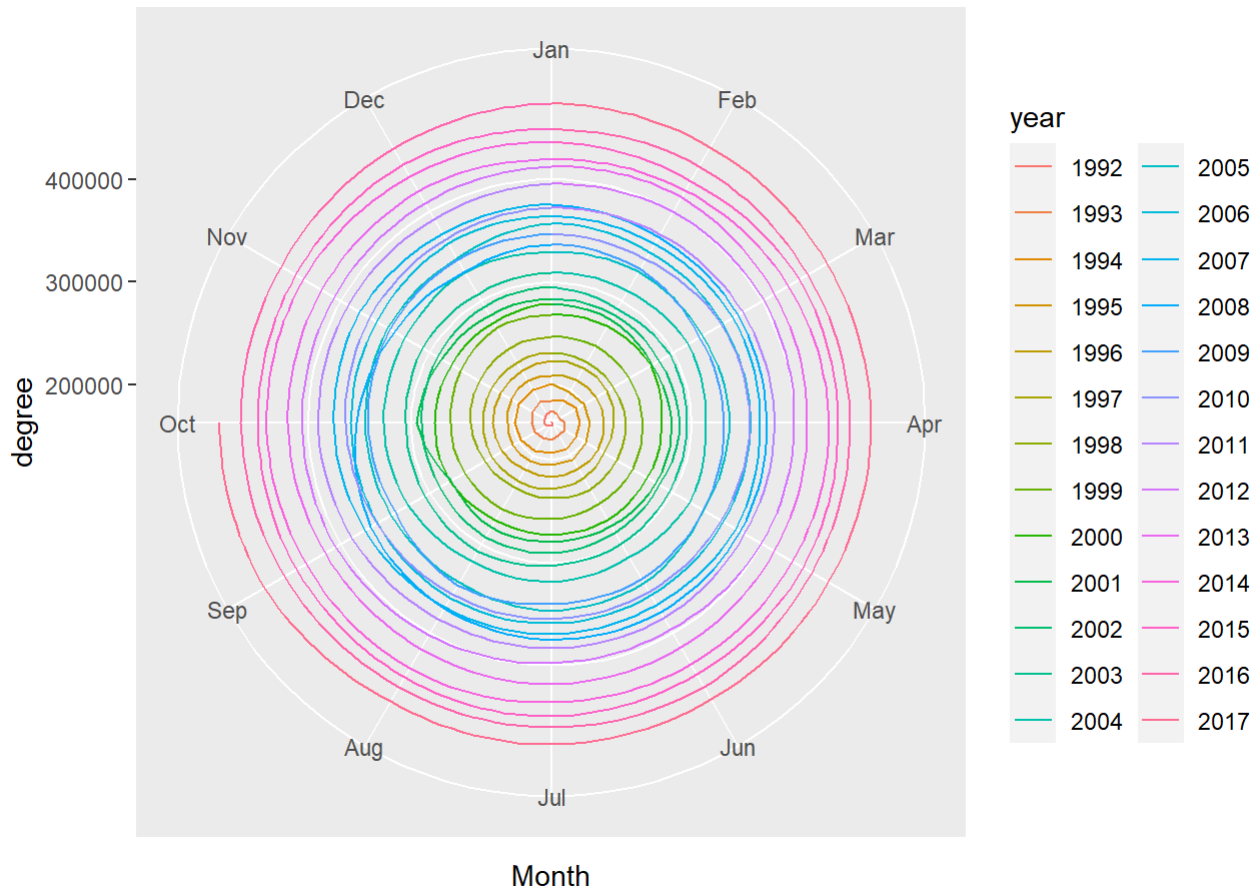

```
monthplot(data_ts)
```
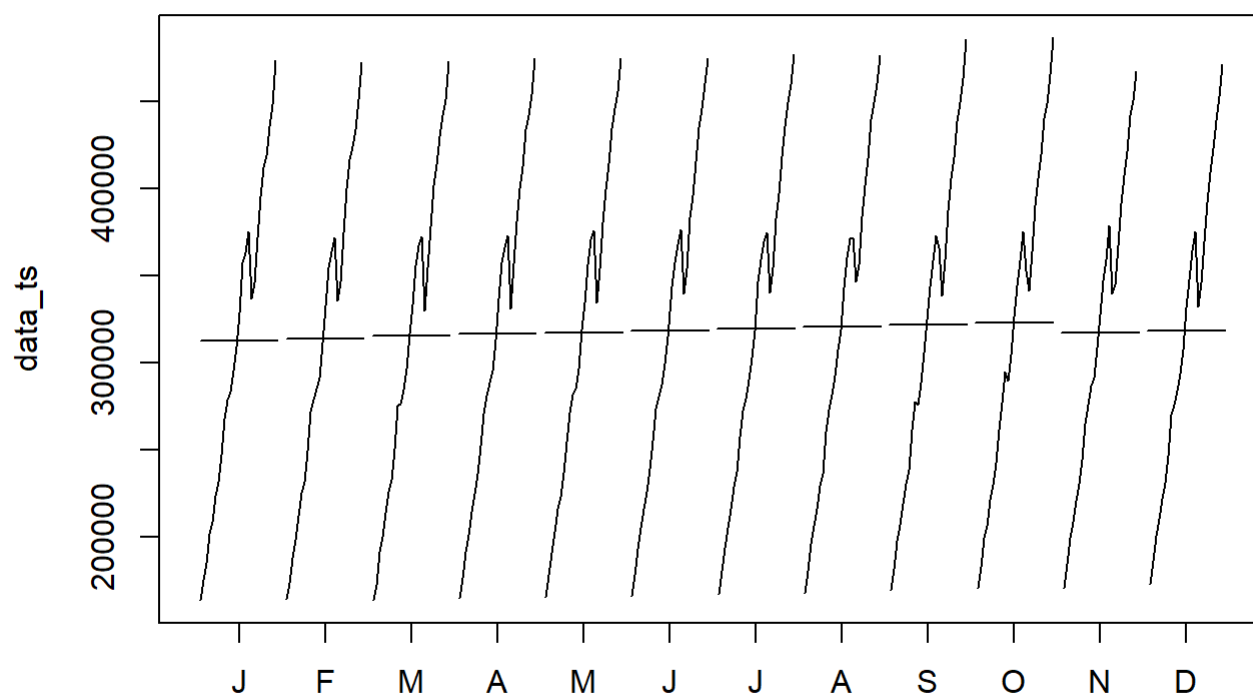
> # *Average sales was a little bit higher in the month of October and August. All months showed so*
> *me irregularities (the bump).*

Decomposition of plot: Mutiplicative Seasonal correction/adjustment

```
data_decompose <- decompose(data_ts, type = "multiplicative")
data_decompose
```

```
## $x
##          Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1992 164083 164260 163747 164759 165617 166098 167305 167797 169407 170681
## 1993 175078 173770 172328 176766 178445 178201 180759 180692 181800 182910
## 1994 185128 188077 191588 191632 190940 193196 193763 196157 197754 199579
## 1995 201583 198383 200230 201048 202993 205507 204959 206529 206978 206157
## 1996 208731 212011 213855 214644 216304 216059 216374 216355 219240 221039
## 1997 223524 225409 226136 224588 222906 226048 228738 229317 230284 229822
## 1998 231605 231664 233043 235976 237055 238958 237423 236412 238542 242531
## 1999 246891 249510 250657 252418 254738 255472 257441 260253 261352 261825
## 2000 268091 272020 275214 271004 271418 273440 272638 272943 277523 276973
## 2001 278916 278799 276468 280804 281540 280399 279522 281423 276095 294613
## 2002 283577 285061 284263 288820 284994 287401 290427 292582 288434 289634
## 2003 295294 291178 296347 295643 296395 299662 302788 307745 305916 304824
## 2004 309225 311427 316935 313531 318962 314971 318532 318945 324607 326680
## 2005 328957 332980 333293 337003 334454 343955 346690 343110 343633 344319
## 2006 357360 354735 355826 357601 356524 357754 359087 360514 358702 358398
## 2007 363520 364090 367414 366280 370867 368080 369500 371019 372936 375217
## 2008 375280 371734 372656 373086 375851 376378 374837 372112 366377 352768
## 2009 336918 335698 329947 331313 334315 339535 340229 346657 338427 341578
## 2010 346252 346835 354564 357095 354267 353811 354457 356505 359326 363736
## 2011 372047 374970 378472 380796 380402 383072 382930 383822 387402 390299
## 2012 395317 400042 401859 400077 399370 395782 397347 401904 405658 405877
## 2013 412125 416603 413848 412655 414182 415777 418222 417503 417565 419693
## 2014 418800 424117 429720 433675 434334 435094 435688 439554 438687 440396
## 2015 435929 434153 442225 442183 446238 446238 449403 449592 449496 448616
## 2016 448171 451209 451274 454231 455753 460563 459744 460198 463045 465368
## 2017 473464 472513 472991 474547 474760 474488 476752 476513 485419 486553
##          Nov    Dec
## 1992 171025 172995
## 1993 184746 186339
## 1994 199723 200670
## 1995 208661 210434
## 1996 220989 221898
## 1997 230486 231197
## 1998 244307 246577
## 1999 264883 269876
## 2000 275923 275736
## 2001 286960 283708
## 2002 291475 293819
## 2003 308551 307362
## 2004 327837 331877
## 2005 347239 347526
## 2006 359208 364270
## 2007 378481 375256
## 2008 339776 332307
## 2009 344579 346215
## 2010 367330 369294
## 2011 391571 391744
## 2012 407386 409343
## 2013 421033 423005
## 2014 442106 439323
```

```
## 2015 450509 452756
## 2016 466974 470996
## 2017
##
## $seasonal
##           Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1992 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1993 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1994 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1995 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1996 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1997 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1998 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 1999 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2000 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2001 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2002 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2003 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2004 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2005 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2006 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2007 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2008 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2009 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2010 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2011 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2012 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2013 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2014 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2015 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2016 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## 2017 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
##          Nov    Dec
## 1992 0.9998 0.9997
## 1993 0.9998 0.9997
## 1994 0.9998 0.9997
## 1995 0.9998 0.9997
## 1996 0.9998 0.9997
## 1997 0.9998 0.9997
## 1998 0.9998 0.9997
## 1999 0.9998 0.9997
## 2000 0.9998 0.9997
## 2001 0.9998 0.9997
## 2002 0.9998 0.9997
## 2003 0.9998 0.9997
## 2004 0.9998 0.9997
## 2005 0.9998 0.9997
## 2006 0.9998 0.9997
## 2007 0.9998 0.9997
## 2008 0.9998 0.9997
## 2009 0.9998 0.9997
## 2010 0.9998 0.9997
```

```
## 2011 0.9998 0.9997
## 2012 0.9998 0.9997
## 2013 0.9998 0.9997
## 2014 0.9998 0.9997
## 2015 0.9998 0.9997
## 2016 0.9998 0.9997
## 2017
##
## $trend
##           Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1992      NA     NA     NA     NA     NA     NA 167773 168627 169381 170239
## 1993 173377 174475 175529 176555 177636 178764 179738 180753 182152 183574
## 1994 187026 188212 189521 190880 192199 193420 194703 195818 196607 197360
## 1995 200249 201148 201964 202623 203269 204048 204753 205619 206754 207888
## 1996 210919 211804 212725 213855 214989 215981 217075 218249 219319 220245
## 1997 222557 223613 224613 225439 226201 226984 227708 228305 228854 229616
## 1998 232707 233365 234004 234878 235984 237200 238478 239858 241336 242755
## 1999 247124 248951 250895 252650 254311 256139 257993 259814 261775 263573
## 2000 267868 269030 270232 271537 272629 273333 274028 274761 275096 275557
## 2001 277675 278316 278609 279285 280480 281272 281798 282253 282839 283498
## 2002 285157 286077 287056 287363 287343 287953 288862 289605 290364 291151
## 2003 293923 295069 296430 297791 299135 300411 301556 302980 304682 306285
## 2004 310842 311965 313211 314900 316614 318439 320283 322003 323583 325242
## 2005 331100 333280 335080 336607 338151 339611 341447 343537 345382 347179
## 2006 351543 352785 354138 355352 356438 357634 358588 359235 360107 360952
## 2007 363803 364675 365705 366999 368503 369764 370712 371520 372057 372559
## 2008 374172 374440 374212 373003 370455 367053 363665 360565 357284 353764
## 2009 344050 341547 339322 337691 337425 338205 339173 340026 341516 343616
## 2010 348135 349138 350420 352214 354085 355994 358031 360278 362446 364430
## 2011 371220 373545 375853 378130 380246 382192 384097 386111 388130 389908
## 2012 393952 395306 396820 398230 399538 400930 402364 403754 404944 405967
## 2013 410262 411782 412928 414000 415144 416282 417129 417720 418695 420232
## 2014 425125 426771 428570 430313 432053 433611 435005 436137 437076 437951
## 2015 440798 441788 442656 443449 444142 445052 446122 447342 448430 449309
## 2016 452229 453101 454108 455370 456754 458200 460014 461956 463748 465500
## 2017 469799 471188 472800 474615     NA     NA     NA     NA     NA     NA
##          Nov    Dec
## 1992 171273 172312
## 1993 184714 185859
## 1994 198254 199270
## 1995 209010 210004
## 1996 220935 221626
## 1997 230680 231807
## 1998 244177 245602
## 1999 265042 266486
## 2000 276387 277099
## 2001 283976 284411
## 2002 291911 292897
## 2003 307970 309549
## 2004 326866 328719
## 2005 348957 350451
## 2006 361911 362939
```

```
## 2007 373050 373604
## 2008 350293 347027
## 2009 345521 346948
## 2010 366507 368815
## 2011 391502 392822
## 2012 407109 408559
## 2013 421947 423592
## 2014 438802 439762
## 2015 450208 451201
## 2016 467138 468510
## 2017
##
## $random
##          Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1992     NA     NA     NA     NA     NA     NA 0.9965 0.9938 1.0006 1.0017
## 1993 1.0112 0.9977 0.9815 1.0008 1.0049 0.9961 1.0049 0.9984 0.9986 0.9955
## 1994 0.9913 1.0010 1.0106 1.0035 0.9938 0.9981 0.9944 1.0004 1.0063 1.0103
## 1995 1.0081 0.9880 0.9911 0.9918 0.9990 1.0064 1.0003 1.0031 1.0016 0.9907
## 1996 0.9910 1.0027 1.0050 1.0033 1.0064 0.9996 0.9960 0.9900 1.0001 1.0027
## 1997 1.0058 1.0098 1.0065 0.9958 0.9858 0.9951 1.0038 1.0031 1.0067 1.0000
## 1998 0.9967 0.9945 0.9956 1.0042 1.0049 1.0066 0.9948 0.9844 0.9889 0.9981
## 1999 1.0005 1.0040 0.9988 0.9986 1.0020 0.9966 0.9971 1.0004 0.9989 0.9924
## 2000 1.0023 1.0129 1.0181 0.9976 0.9959 0.9996 0.9942 0.9921 1.0093 1.0042
## 2001 1.0059 1.0035 0.9920 1.0050 1.0041 0.9961 0.9912 0.9958 0.9766 1.0382
## 2002 0.9959 0.9982 0.9900 1.0046 0.9921 0.9973 1.0047 1.0090 0.9938 0.9939
## 2003 1.0061 0.9886 0.9994 0.9924 0.9912 0.9967 1.0033 1.0144 1.0045 0.9943
## 2004 0.9962 1.0000 1.0116 0.9952 1.0077 0.9883 0.9938 0.9892 1.0037 1.0035
## 2005 0.9949 1.0009 0.9944 1.0007 0.9894 1.0120 1.0146 0.9975 0.9954 0.9908
## 2006 1.0180 1.0073 1.0045 1.0059 1.0006 0.9996 1.0006 1.0023 0.9966 0.9920
## 2007 1.0006 1.0002 1.0044 0.9976 1.0067 0.9947 0.9960 0.9974 1.0029 1.0062
## 2008 1.0044 0.9945 0.9956 0.9998 1.0149 1.0246 1.0299 1.0307 1.0260 0.9963
## 2009 0.9807 0.9846 0.9721 0.9807 0.9911 1.0032 1.0024 1.0182 0.9914 0.9931
## 2010 0.9960 0.9952 1.0115 1.0134 1.0008 0.9931 0.9893 0.9882 0.9919 0.9972
## 2011 1.0037 1.0056 1.0067 1.0066 1.0007 1.0015 0.9962 0.9928 0.9986 1.0001
## 2012 1.0049 1.0138 1.0124 1.0042 0.9999 0.9864 0.9868 0.9941 1.0023 0.9988
## 2013 1.0060 1.0135 1.0019 0.9963 0.9980 0.9980 1.0019 0.9982 0.9978 0.9978
## 2014 0.9865 0.9955 1.0024 1.0074 1.0056 1.0026 1.0008 1.0065 1.0042 1.0046
## 2015 0.9904 0.9845 0.9987 0.9967 1.0050 1.0019 1.0066 1.0037 1.0029 0.9975
## 2016 0.9924 0.9976 0.9935 0.9971 0.9981 1.0044 0.9987 0.9949 0.9990 0.9988
## 2017 1.0092 1.0046 1.0001 0.9994     NA     NA     NA     NA     NA     NA
##          Nov    Dec
## 1992 0.9987 1.0043
## 1993 1.0004 1.0029
## 1994 1.0076 1.0073
## 1995 0.9985 1.0023
## 1996 1.0004 1.0015
## 1997 0.9993 0.9977
## 1998 1.0007 1.0043
## 1999 0.9996 1.0130
## 2000 0.9985 0.9954
## 2001 1.0107 0.9978
## 2002 0.9987 1.0034
```

```
## 2003 1.0021 0.9932
## 2004 1.0031 1.0099
## 2005 0.9953 0.9919
## 2006 0.9927 1.0040
## 2007 1.0147 1.0047
## 2008 0.9701 0.9579
## 2009 0.9974 0.9982
## 2010 1.0024 1.0016
## 2011 1.0004 0.9976
## 2012 1.0009 1.0022
## 2013 0.9980 0.9989
## 2014 1.0077 0.9993
## 2015 1.0008 1.0037
## 2016 0.9998 1.0056
## 2017
##
## $figure
##  [1] 0.9986 0.9982 1.0003 1.0004 0.9997 1.0008 1.0008 1.0013 0.9995 1.0009
## [11] 0.9998 0.9997
##
## $type
## [1] "multiplicative"
##
## attr(,"class")
## [1] "decomposed.ts"
```

```
#Observation:

# On the seasonal part: in January for all years, retail sales is 99% of the annual trend (and
 1% less) and etc. In August, retail sales is about 1.0013 more.

# On the random part: January, 1993, retail sales was about 1% more than where it should be afte
r accounting for trend and seasonality. March, 1993;retail sales was about 2% left than the tren
d and seasonality forecast.




plot(data_decompose)
```

Decomposition of multiplicative time series
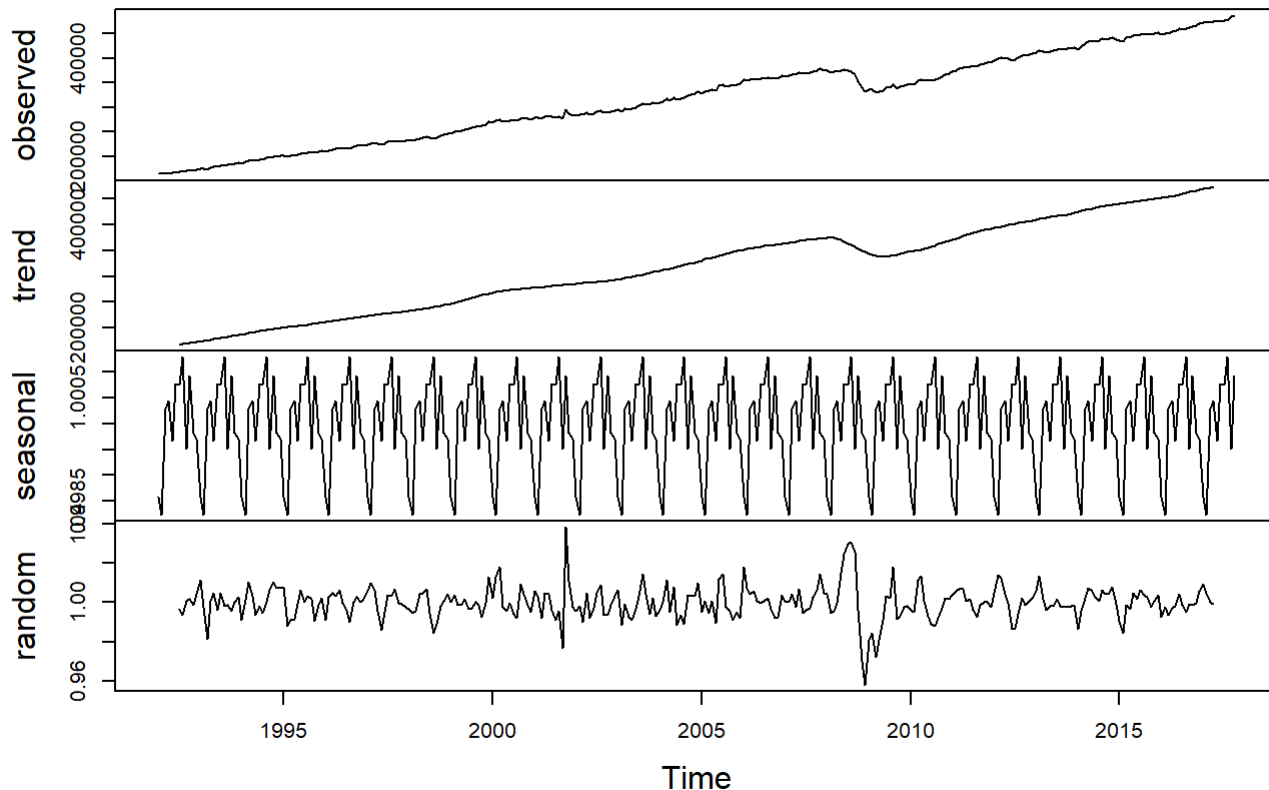

```
# the trend is increasing though there is a flattening in 2008.
# The seasonal part is repeating.
# On random: My unpredictable error is about 4% (0.96). In the future, i don't know what the num
ber will be, but my best guess is in the middle (1).
```

Splittig data into training and test sets and test the last 2 years

```
data_train <- window(data_ts, start=c(1992,1),end=c(2015,12), freq=12)
data_train
```

```
##        Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1992 164083 164260 163747 164759 165617 166098 167305 167797 169407 170681
## 1993 175078 173770 172328 176766 178445 178201 180759 180692 181800 182910
## 1994 185128 188077 191588 191632 190940 193196 193763 196157 197754 199579
## 1995 201583 198383 200230 201048 202993 205507 204959 206529 206978 206157
## 1996 208731 212011 213855 214644 216304 216059 216374 216355 219240 221039
## 1997 223524 225409 226136 224588 222906 226048 228738 229317 230284 229822
## 1998 231605 231664 233043 235976 237055 238958 237423 236412 238542 242531
## 1999 246891 249510 250657 252418 254738 255472 257441 260253 261352 261825
## 2000 268091 272020 275214 271004 271418 273440 272638 272943 277523 276973
## 2001 278916 278799 276468 280804 281540 280399 279522 281423 276095 294613
## 2002 283577 285061 284263 288820 284994 287401 290427 292582 288434 289634
## 2003 295294 291178 296347 295643 296395 299662 302788 307745 305916 304824
## 2004 309225 311427 316935 313531 318962 314971 318532 318945 324607 326680
## 2005 328957 332980 333293 337003 334454 343955 346690 343110 343633 344319
## 2006 357360 354735 355826 357601 356524 357754 359087 360514 358702 358398
## 2007 363520 364090 367414 366280 370867 368080 369500 371019 372936 375217
## 2008 375280 371734 372656 373086 375851 376378 374837 372112 366377 352768
## 2009 336918 335698 329947 331313 334315 339535 340229 346657 338427 341578
## 2010 346252 346835 354564 357095 354267 353811 354457 356505 359326 363736
## 2011 372047 374970 378472 380796 380402 383072 382930 383822 387402 390299
## 2012 395317 400042 401859 400077 399370 395782 397347 401904 405658 405877
## 2013 412125 416603 413848 412655 414182 415777 418222 417503 417565 419693
## 2014 418800 424117 429720 433675 434334 435094 435688 439554 438687 440396
## 2015 435929 434153 442225 442183 446238 446238 449403 449592 449496 448616
##         Nov    Dec
## 1992 171025 172995
## 1993 184746 186339
## 1994 199723 200670
## 1995 208661 210434
## 1996 220989 221898
## 1997 230486 231197
## 1998 244307 246577
## 1999 264883 269876
## 2000 275923 275736
## 2001 286960 283708
## 2002 291475 293819
## 2003 308551 307362
## 2004 327837 331877
## 2005 347239 347526
## 2006 359208 364270
## 2007 378481 375256
## 2008 339776 332307
## 2009 344579 346215
## 2010 367330 369294
## 2011 391571 391744
## 2012 407386 409343
## 2013 421033 423005
## 2014 442106 439323
## 2015 450509 452756
```

```
data_test <- window(data_ts, start=c(2016,1), freq=12)
data_test
```

```
##           Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 2016 448171 451209 451274 454231 455753 460563 459744 460198 463045 465368
## 2017 473464 472513 472991 474547 474760 474488 476752 476513 485419 486553
##           Nov    Dec
## 2016 466974 470996
## 2017
```

```
autoplot(data_train, series = "Train") + autolayer(data_test, series = "Test") + ggtitle("Retail
sales train and test set") +xlab("year") +ylab("sales")+guides(colour=guide_legend(title = "Fore
cast"))
```


Retail sales train and test set
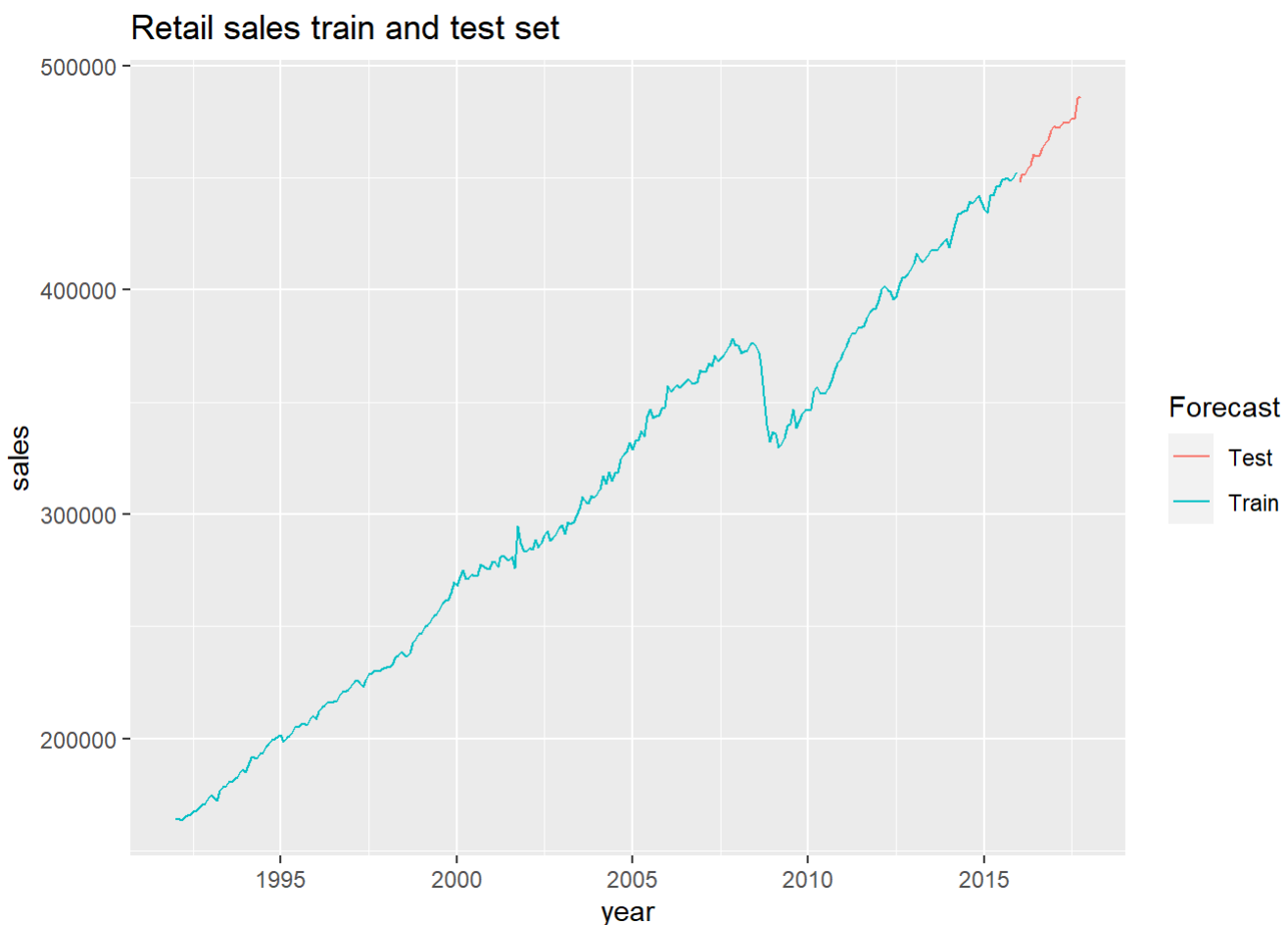
Data Forcast using Seasonal Naive Method

```
data_naive <- snaive(data_ts, level = c(95), h = 10*12)
data_naive
```

```
##          Point Forecast  Lo 95  Hi 95
## Nov 2017          466974 433589 500359
## Dec 2017          470996 437611 504381
## Jan 2018          473464 440079 506849
## Feb 2018          472513 439128 505898
## Mar 2018          472991 439606 506376
## Apr 2018          474547 441162 507932
## May 2018          474760 441375 508145
## Jun 2018          474488 441103 507873
## Jul 2018          476752 443367 510137
## Aug 2018          476513 443128 509898
## Sep 2018          485419 452034 518804
## Oct 2018          486553 453168 519938
## Nov 2018          466974 419761 514187
## Dec 2018          470996 423783 518209
## Jan 2019          473464 426251 520677
## Feb 2019          472513 425300 519726
## Mar 2019          472991 425778 520204
## Apr 2019          474547 427334 521760
## May 2019          474760 427547 521973
## Jun 2019          474488 427275 521701
## Jul 2019          476752 429539 523965
## Aug 2019          476513 429300 523726
## Sep 2019          485419 438206 532632
## Oct 2019          486553 439340 533766
## Nov 2019          466974 409150 524798
## Dec 2019          470996 413172 528820
## Jan 2020          473464 415640 531288
## Feb 2020          472513 414689 530337
## Mar 2020          472991 415167 530815
## Apr 2020          474547 416723 532371
## May 2020          474760 416936 532584
## Jun 2020          474488 416664 532312
## Jul 2020          476752 418928 534576
## Aug 2020          476513 418689 534337
## Sep 2020          485419 427595 543243
## Oct 2020          486553 428729 544377
## Nov 2020          466974 400205 533743
## Dec 2020          470996 404227 537765
## Jan 2021          473464 406695 540233
## Feb 2021          472513 405744 539282
## Mar 2021          472991 406222 539760
## Apr 2021          474547 407778 541316
## May 2021          474760 407991 541529
## Jun 2021          474488 407719 541257
## Jul 2021          476752 409983 543521
## Aug 2021          476513 409744 543282
## Sep 2021          485419 418650 552188
## Oct 2021          486553 419784 553322
## Nov 2021          466974 392324 541624
## Dec 2021          470996 396346 545646
## Jan 2022          473464 398814 548114
```

```
## Feb 2022          472513 397863 547163
## Mar 2022          472991 398341 547641
## Apr 2022          474547 399897 549197
## May 2022          474760 400110 549410
## Jun 2022          474488 399838 549138
## Jul 2022          476752 402102 551402
## Aug 2022          476513 401863 551163
## Sep 2022          485419 410769 560069
## Oct 2022          486553 411903 561203
## Nov 2022          466974 385199 548749
## Dec 2022          470996 389221 552771
## Jan 2023          473464 391689 555239
## Feb 2023          472513 390738 554288
## Mar 2023          472991 391216 554766
## Apr 2023          474547 392772 556322
## May 2023          474760 392985 556535
## Jun 2023          474488 392713 556263
## Jul 2023          476752 394977 558527
## Aug 2023          476513 394738 558288
## Sep 2023          485419 403644 567194
## Oct 2023          486553 404778 568328
## Nov 2023          466974 378646 555302
## Dec 2023          470996 382668 559324
## Jan 2024          473464 385136 561792
## Feb 2024          472513 384185 560841
## Mar 2024          472991 384663 561319
## Apr 2024          474547 386219 562875
## May 2024          474760 386432 563088
## Jun 2024          474488 386160 562816
## Jul 2024          476752 388424 565080
## Aug 2024          476513 388185 564841
## Sep 2024          485419 397091 573747
## Oct 2024          486553 398225 574881
## Nov 2024          466974 372548 561400
## Dec 2024          470996 376570 565422
## Jan 2025          473464 379038 567890
## Feb 2025          472513 378087 566939
## Mar 2025          472991 378565 567417
## Apr 2025          474547 380121 568973
## May 2025          474760 380334 569186
## Jun 2025          474488 380062 568914
## Jul 2025          476752 382326 571178
## Aug 2025          476513 382087 570939
## Sep 2025          485419 390993 579845
## Oct 2025          486553 392127 580979
## Nov 2025          466974 366820 567128
## Dec 2025          470996 370842 571150
## Jan 2026          473464 373310 573618
## Feb 2026          472513 372359 572667
## Mar 2026          472991 372837 573145
## Apr 2026          474547 374393 574701
## May 2026          474760 374606 574914
```

```
## Jun 2026          474488 374334 574642
## Jul 2026          476752 376598 576906
## Aug 2026          476513 376359 576667
## Sep 2026          485419 385265 585573
## Oct 2026          486553 386399 586707
## Nov 2026          466974 361402 572546
## Dec 2026          470996 365424 576568
## Jan 2027          473464 367892 579036
## Feb 2027          472513 366941 578085
## Mar 2027          472991 367419 578563
## Apr 2027          474547 368975 580119
## May 2027          474760 369188 580332
## Jun 2027          474488 368916 580060
## Jul 2027          476752 371180 582324
## Aug 2027          476513 370941 582085
## Sep 2027          485419 379847 590991
## Oct 2027          486553 380981 592125
```

```
print(summary(data_naive))
```

```
##
## Forecast method: Seasonal naive method
##
## Model Information:
## Call: snaive(y = data_ts, h = 10 * 12, level = c(95))
##
## Residual sd: 17033.3071
##
## Error measures:
##                  ME  RMSE   MAE   MPE  MAPE MASE   ACF1
## Training set 12410 17033 15454 4.055 4.959    1 0.9256
##
## Forecasts:
##          Point Forecast   Lo 95  Hi 95
## Nov 2017         466974  433589 500359
## Dec 2017         470996  437611 504381
## Jan 2018         473464  440079 506849
## Feb 2018         472513  439128 505898
## Mar 2018         472991  439606 506376
## Apr 2018         474547  441162 507932
## May 2018         474760  441375 508145
## Jun 2018         474488  441103 507873
## Jul 2018         476752  443367 510137
## Aug 2018         476513  443128 509898
## Sep 2018         485419  452034 518804
## Oct 2018         486553  453168 519938
## Nov 2018         466974  419761 514187
## Dec 2018         470996  423783 518209
## Jan 2019         473464  426251 520677
## Feb 2019         472513  425300 519726
## Mar 2019         472991  425778 520204
## Apr 2019         474547  427334 521760
## May 2019         474760  427547 521973
## Jun 2019         474488  427275 521701
## Jul 2019         476752  429539 523965
## Aug 2019         476513  429300 523726
## Sep 2019         485419  438206 532632
## Oct 2019         486553  439340 533766
## Nov 2019         466974  409150 524798
## Dec 2019         470996  413172 528820
## Jan 2020         473464  415640 531288
## Feb 2020         472513  414689 530337
## Mar 2020         472991  415167 530815
## Apr 2020         474547  416723 532371
## May 2020         474760  416936 532584
## Jun 2020         474488  416664 532312
## Jul 2020         476752  418928 534576
## Aug 2020         476513  418689 534337
## Sep 2020         485419  427595 543243
## Oct 2020         486553  428729 544377
## Nov 2020         466974  400205 533743
## Dec 2020         470996  404227 537765
```

```
## Jan 2021           473464 406695 540233
## Feb 2021           472513 405744 539282
## Mar 2021           472991 406222 539760
## Apr 2021           474547 407778 541316
## May 2021           474760 407991 541529
## Jun 2021           474488 407719 541257
## Jul 2021           476752 409983 543521
## Aug 2021           476513 409744 543282
## Sep 2021           485419 418650 552188
## Oct 2021           486553 419784 553322
## Nov 2021           466974 392324 541624
## Dec 2021           470996 396346 545646
## Jan 2022           473464 398814 548114
## Feb 2022           472513 397863 547163
## Mar 2022           472991 398341 547641
## Apr 2022           474547 399897 549197
## May 2022           474760 400110 549410
## Jun 2022           474488 399838 549138
## Jul 2022           476752 402102 551402
## Aug 2022           476513 401863 551163
## Sep 2022           485419 410769 560069
## Oct 2022           486553 411903 561203
## Nov 2022           466974 385199 548749
## Dec 2022           470996 389221 552771
## Jan 2023           473464 391689 555239
## Feb 2023           472513 390738 554288
## Mar 2023           472991 391216 554766
## Apr 2023           474547 392772 556322
## May 2023           474760 392985 556535
## Jun 2023           474488 392713 556263
## Jul 2023           476752 394977 558527
## Aug 2023           476513 394738 558288
## Sep 2023           485419 403644 567194
## Oct 2023           486553 404778 568328
## Nov 2023           466974 378646 555302
## Dec 2023           470996 382668 559324
## Jan 2024           473464 385136 561792
## Feb 2024           472513 384185 560841
## Mar 2024           472991 384663 561319
## Apr 2024           474547 386219 562875
## May 2024           474760 386432 563088
## Jun 2024           474488 386160 562816
## Jul 2024           476752 388424 565080
## Aug 2024           476513 388185 564841
## Sep 2024           485419 397091 573747
## Oct 2024           486553 398225 574881
## Nov 2024           466974 372548 561400
## Dec 2024           470996 376570 565422
## Jan 2025           473464 379038 567890
## Feb 2025           472513 378087 566939
## Mar 2025           472991 378565 567417
## Apr 2025           474547 380121 568973
```

```
## May 2025         474760 380334 569186
## Jun 2025         474488 380062 568914
## Jul 2025         476752 382326 571178
## Aug 2025         476513 382087 570939
## Sep 2025         485419 390993 579845
## Oct 2025         486553 392127 580979
## Nov 2025         466974 366820 567128
## Dec 2025         470996 370842 571150
## Jan 2026         473464 373310 573618
## Feb 2026         472513 372359 572667
## Mar 2026         472991 372837 573145
## Apr 2026         474547 374393 574701
## May 2026         474760 374606 574914
## Jun 2026         474488 374334 574642
## Jul 2026         476752 376598 576906
## Aug 2026         476513 376359 576667
## Sep 2026         485419 385265 585573
## Oct 2026         486553 386399 586707
## Nov 2026         466974 361402 572546
## Dec 2026         470996 365424 576568
## Jan 2027         473464 367892 579036
## Feb 2027         472513 366941 578085
## Mar 2027         472991 367419 578563
## Apr 2027         474547 368975 580119
## May 2027         474760 369188 580332
## Jun 2027         474488 368916 580060
## Jul 2027         476752 371180 582324
## Aug 2027         476513 370941 582085
## Sep 2027         485419 379847 590991
## Oct 2027         486553 380981 592125
```

```
# resdiual sd : 17033.3071
checkresiduals(data_naive)
```

Residuals from Seasonal naive method
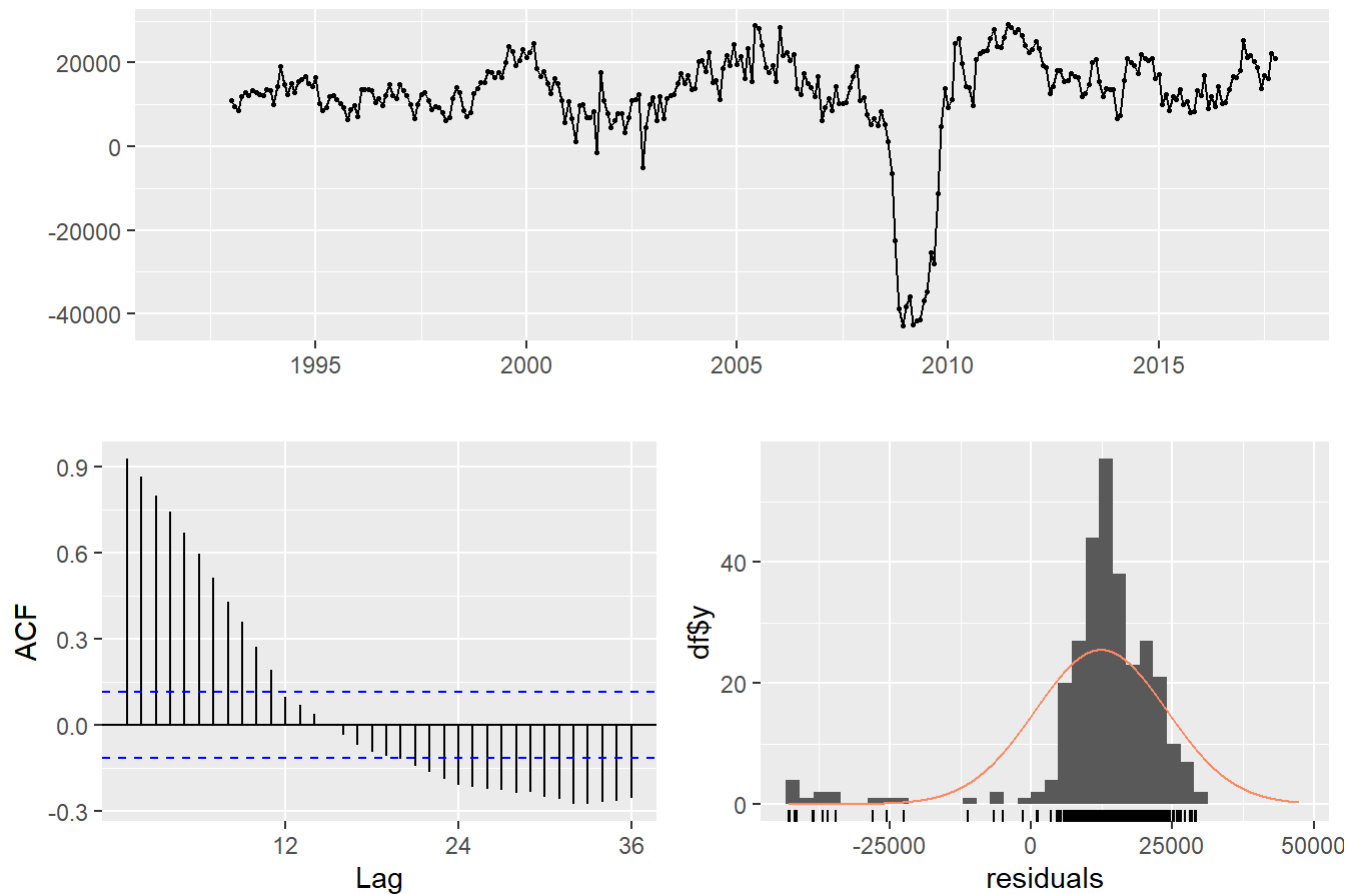

```
## 
##  Ljung-Box test
## 
## data:  Residuals from Seasonal naive method
## Q* = 1359, df = 24, p-value <0.0000000000000002
## 
## Model df: 0.    Total lags used: 24
```

Data Forecasting Using ARIMA methods

To check for stationarity

```
acf(data_ts)
```

Series data_ts
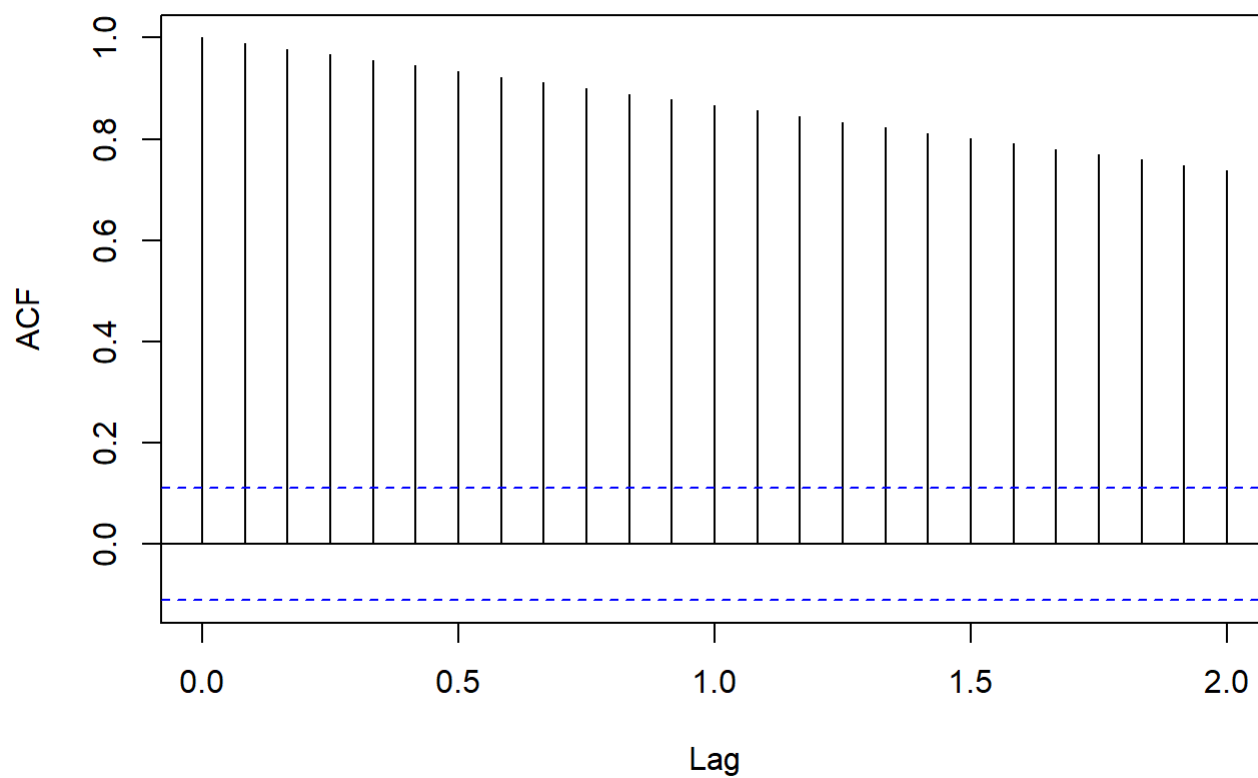

```
# it is not stationary (auto correlation because the spikes cross above the blue lines)


pacf(data_ts)
```

Series data_ts
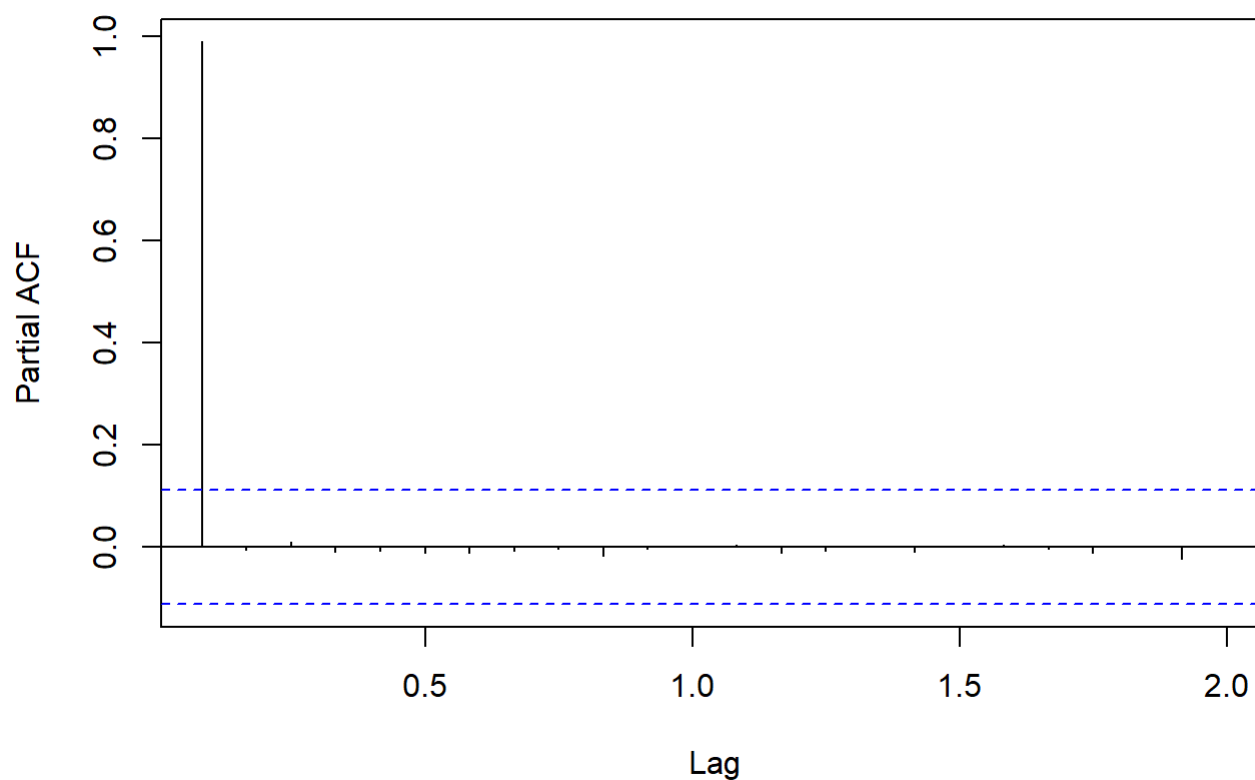

```
# partial okay as the spikes are not much.

adf.test(data_ts)
```

```
##
##   Augmented Dickey-Fuller Test
##
## data:  data_ts
## Dickey-Fuller = -2.3, Lag order = 6, p-value = 0.4
## alternative hypothesis: stationary
```

```
# p-value is higher than 0.05


# Converting non-stationary data to stationary data

new_arima <- auto.arima(data_ts, d=1, D=1,stepwise = F, approximation = F, trace = T)
```

```
## 
##  ARIMA(0,1,0)(0,1,0)[12]                     : 5839
##  ARIMA(0,1,0)(0,1,1)[12]                     : Inf
##  ARIMA(0,1,0)(0,1,2)[12]                     : Inf
##  ARIMA(0,1,0)(1,1,0)[12]                     : 5769
##  ARIMA(0,1,0)(1,1,1)[12]                     : Inf
##  ARIMA(0,1,0)(1,1,2)[12]                     : Inf
##  ARIMA(0,1,0)(2,1,0)[12]                     : 5717
##  ARIMA(0,1,0)(2,1,1)[12]                     : Inf
##  ARIMA(0,1,0)(2,1,2)[12]                     : Inf
##  ARIMA(0,1,1)(0,1,0)[12]                     : 5838
##  ARIMA(0,1,1)(0,1,1)[12]                     : Inf
##  ARIMA(0,1,1)(0,1,2)[12]                     : Inf
##  ARIMA(0,1,1)(1,1,0)[12]                     : 5770
##  ARIMA(0,1,1)(1,1,1)[12]                     : Inf
##  ARIMA(0,1,1)(1,1,2)[12]                     : Inf
##  ARIMA(0,1,1)(2,1,0)[12]                     : 5719
##  ARIMA(0,1,1)(2,1,1)[12]                     : Inf
##  ARIMA(0,1,1)(2,1,2)[12]                     : Inf
##  ARIMA(0,1,2)(0,1,0)[12]                     : 5840
##  ARIMA(0,1,2)(0,1,1)[12]                     : Inf
##  ARIMA(0,1,2)(0,1,2)[12]                     : Inf
##  ARIMA(0,1,2)(1,1,0)[12]                     : 5772
##  ARIMA(0,1,2)(1,1,1)[12]                     : Inf
##  ARIMA(0,1,2)(1,1,2)[12]                     : Inf
##  ARIMA(0,1,2)(2,1,0)[12]                     : 5719
##  ARIMA(0,1,2)(2,1,1)[12]                     : Inf
##  ARIMA(0,1,3)(0,1,0)[12]                     : 5841
##  ARIMA(0,1,3)(0,1,1)[12]                     : Inf
##  ARIMA(0,1,3)(0,1,2)[12]                     : Inf
##  ARIMA(0,1,3)(1,1,0)[12]                     : 5774
##  ARIMA(0,1,3)(1,1,1)[12]                     : Inf
##  ARIMA(0,1,3)(2,1,0)[12]                     : 5720
##  ARIMA(0,1,4)(0,1,0)[12]                     : 5838
##  ARIMA(0,1,4)(0,1,1)[12]                     : Inf
##  ARIMA(0,1,4)(1,1,0)[12]                     : 5773
##  ARIMA(0,1,5)(0,1,0)[12]                     : 5840
##  ARIMA(1,1,0)(0,1,0)[12]                     : 5838
##  ARIMA(1,1,0)(0,1,1)[12]                     : Inf
##  ARIMA(1,1,0)(0,1,2)[12]                     : Inf
##  ARIMA(1,1,0)(1,1,0)[12]                     : 5770
##  ARIMA(1,1,0)(1,1,1)[12]                     : Inf
##  ARIMA(1,1,0)(1,1,2)[12]                     : Inf
##  ARIMA(1,1,0)(2,1,0)[12]                     : Inf
##  ARIMA(1,1,0)(2,1,1)[12]                     : Inf
##  ARIMA(1,1,0)(2,1,2)[12]                     : Inf
##  ARIMA(1,1,1)(0,1,0)[12]                     : 5838
##  ARIMA(1,1,1)(0,1,1)[12]                     : Inf
##  ARIMA(1,1,1)(0,1,2)[12]                     : Inf
##  ARIMA(1,1,1)(1,1,0)[12]                     : 5770
##  ARIMA(1,1,1)(1,1,1)[12]                     : Inf
##  ARIMA(1,1,1)(1,1,2)[12]                     : Inf
```

```
## ARIMA(1,1,1)(2,1,0)[12]                     : 5719
## ARIMA(1,1,1)(2,1,1)[12]                     : Inf
## ARIMA(1,1,2)(0,1,0)[12]                     : 5840
## ARIMA(1,1,2)(0,1,1)[12]                     : Inf
## ARIMA(1,1,2)(0,1,2)[12]                     : Inf
## ARIMA(1,1,2)(1,1,0)[12]                     : 5773
## ARIMA(1,1,2)(1,1,1)[12]                     : Inf
## ARIMA(1,1,2)(2,1,0)[12]                     : 5718
## ARIMA(1,1,3)(0,1,0)[12]                     : 5840
## ARIMA(1,1,3)(0,1,1)[12]                     : Inf
## ARIMA(1,1,3)(1,1,0)[12]                     : 5775
## ARIMA(1,1,4)(0,1,0)[12]                     : 5838
## ARIMA(2,1,0)(0,1,0)[12]                     : 5840
## ARIMA(2,1,0)(0,1,1)[12]                     : Inf
## ARIMA(2,1,0)(0,1,2)[12]                     : Inf
## ARIMA(2,1,0)(1,1,0)[12]                     : 5771
## ARIMA(2,1,0)(1,1,1)[12]                     : Inf
## ARIMA(2,1,0)(1,1,2)[12]                     : Inf
## ARIMA(2,1,0)(2,1,0)[12]                     : 5718
## ARIMA(2,1,0)(2,1,1)[12]                     : Inf
## ARIMA(2,1,1)(0,1,0)[12]                     : 5840
## ARIMA(2,1,1)(0,1,1)[12]                     : Inf
## ARIMA(2,1,1)(0,1,2)[12]                     : Inf
## ARIMA(2,1,1)(1,1,0)[12]                     : 5772
## ARIMA(2,1,1)(1,1,1)[12]                     : Inf
## ARIMA(2,1,1)(2,1,0)[12]                     : 5718
## ARIMA(2,1,2)(0,1,0)[12]                     : Inf
## ARIMA(2,1,2)(0,1,1)[12]                     : Inf
## ARIMA(2,1,2)(1,1,0)[12]                     : Inf
## ARIMA(2,1,3)(0,1,0)[12]                     : Inf
## ARIMA(3,1,0)(0,1,0)[12]                     : 5840
## ARIMA(3,1,0)(0,1,1)[12]                     : Inf
## ARIMA(3,1,0)(0,1,2)[12]                     : Inf
## ARIMA(3,1,0)(1,1,0)[12]                     : 5773
## ARIMA(3,1,0)(1,1,1)[12]                     : Inf
## ARIMA(3,1,0)(2,1,0)[12]                     : 5720
## ARIMA(3,1,1)(0,1,0)[12]                     : 5840
## ARIMA(3,1,1)(0,1,1)[12]                     : Inf
## ARIMA(3,1,1)(1,1,0)[12]                     : 5774
## ARIMA(3,1,2)(0,1,0)[12]                     : Inf
## ARIMA(4,1,0)(0,1,0)[12]                     : 5838
## ARIMA(4,1,0)(0,1,1)[12]                     : Inf
## ARIMA(4,1,0)(1,1,0)[12]                     : 5773
## ARIMA(4,1,1)(0,1,0)[12]                     : 5840
## ARIMA(5,1,0)(0,1,0)[12]                     : 5840
## 
## 
## 
## Best model: ARIMA(0,1,0)(2,1,0)[12]
```

```
new_arima
```
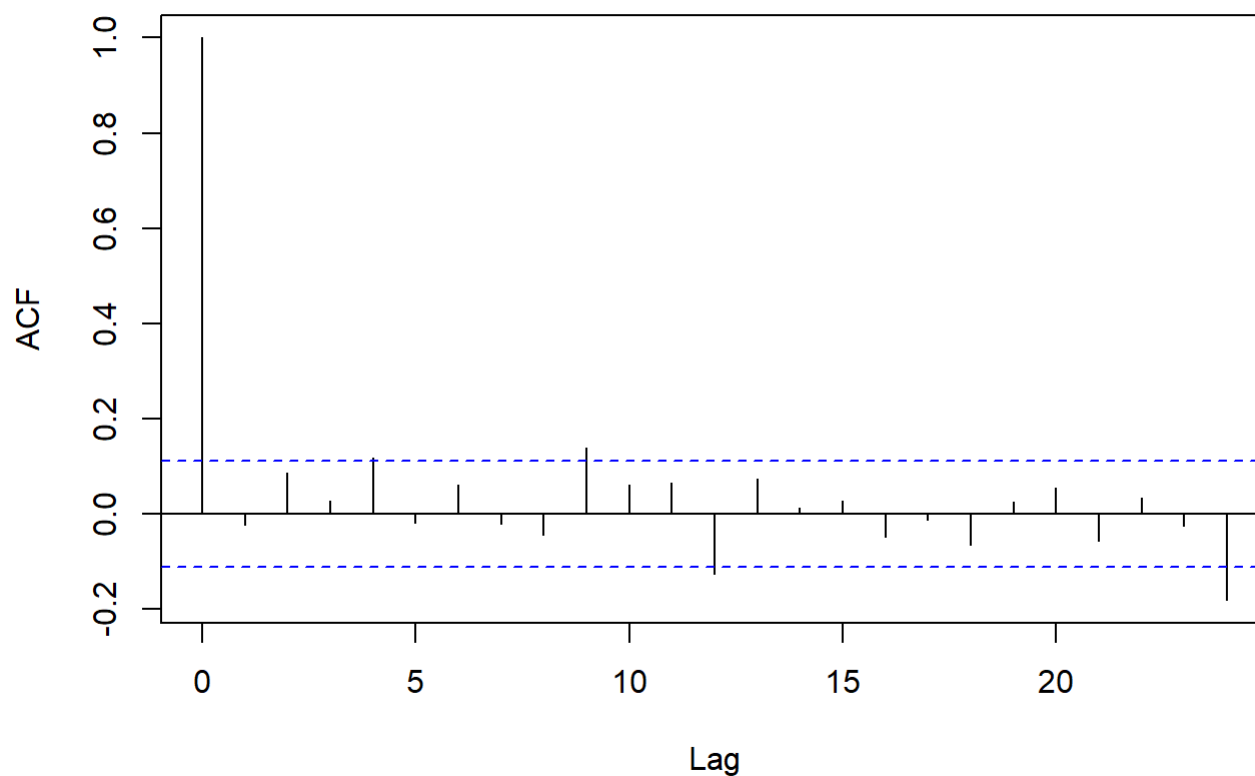
```
## Series: data_ts
## ARIMA(0,1,0)(2,1,0)[12]
##
## Coefficients:
##          sar1     sar2
##        -0.656   -0.409
## s.e.    0.053    0.052
##
## sigma^2 = 12890146:  log likelihood = -2855
## AIC=5717    AICc=5717    BIC=5728
```

```
# The best model has the lowest aic


# To check if the new model is stationary

acf(ts(new_arima$residuals))
```

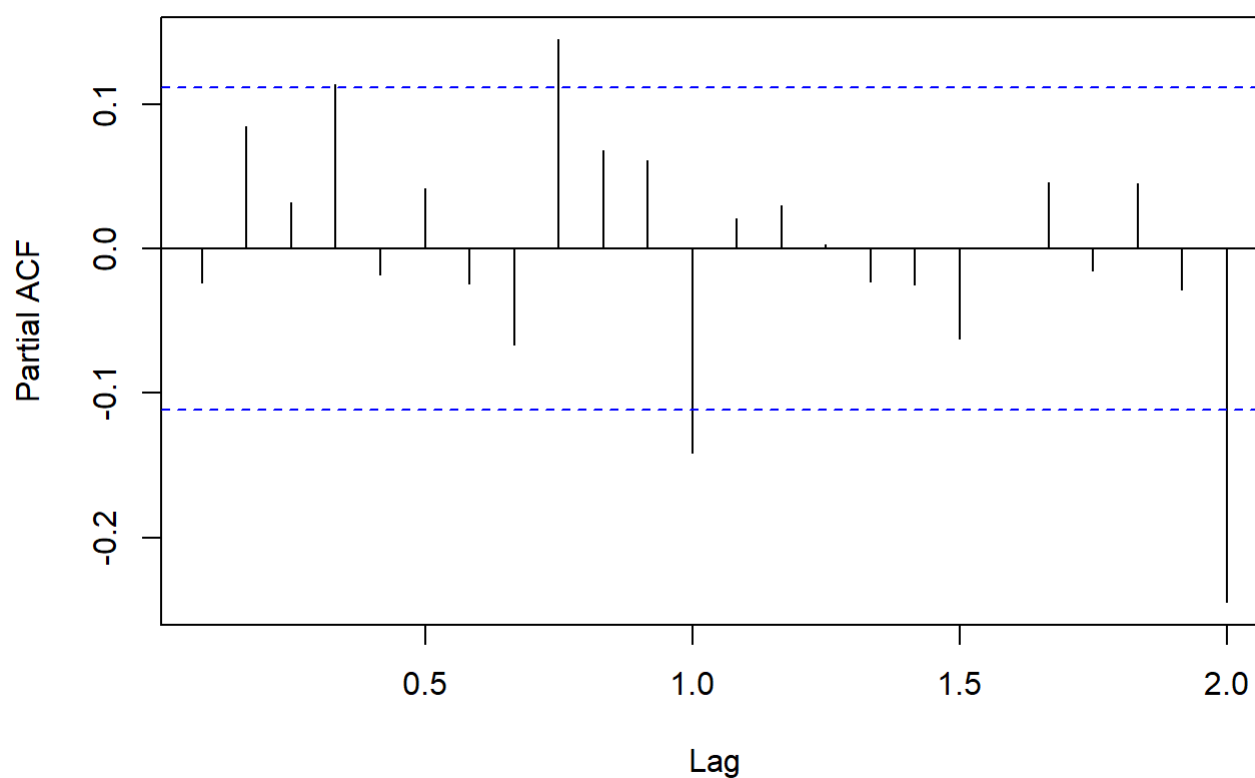## Series ts(new_arima$residuals)


```
# it is okay

pacf(new_arima$residuals)
```

Series new_arima$residuals


```
# it is also okay

adf.test(new_arima$residuals)
```

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

```
##
##  Augmented Dickey-Fuller Test
##
## data:  new_arima$residuals
## Dickey-Fuller = -5.8, Lag order = 6, p-value = 0.01
## alternative hypothesis: stationary
```

```
# the P-value is lower than 0.05
```

Retail sales and services forecasting

```
data_forecast <- forecast(new_arima, level = c(95), h=10*12)
data_forecast
```

```
##           Point Forecast  Lo 95   Hi 95
## Nov 2017          488272 481236 495309
## Dec 2017          489076 479124 499028
## Jan 2018          487407 475219 499595
## Feb 2018          487104 473031 501178
## Mar 2018          490583 474848 506318
## Apr 2018          491832 474595 509069
## May 2018          493938 475320 512556
## Jun 2018          495032 475129 514935
## Jul 2018          496903 475792 518013
## Aug 2018          497010 474757 519262
## Sep 2018          500742 477403 524080
## Oct 2018          501347 476970 525723
## Nov 2018          503109 476961 529257
## Dec 2018          505297 477490 533104
## Jan 2019          503459 474086 532831
## Feb 2019          504361 473502 535219
## Mar 2019          505704 473427 537980
## Apr 2019          507726 474092 541360
## May 2019          509126 474186 544066
## Jun 2019          511401 475203 547599
## Jul 2019          512270 474856 549684
## Aug 2019          512433 473842 551025
## Sep 2019          517081 477347 556816
## Oct 2019          518519 477674 559364
## Nov 2019          520207 477626 562788
## Dec 2019          522802 478553 567051
## Jan 2020          522765 476909 568621
## Feb 2020          522612 475203 570021
## Mar 2020          524129 475217 573042
## Apr 2020          525770 475399 576141
## May 2020          526860 475071 578648
## Jun 2020          527802 474634 580971
## Jul 2020          529489 474975 584002
## Aug 2020          529474 473648 585300
## Sep 2020          535635 478527 592743
## Oct 2020          536743 478381 595105
## Nov 2020          538462 477841 599083
## Dec 2020          540225 477426 603024
## Jan 2021          539076 474173 603980
## Feb 2021          539123 472181 606065
## Mar 2021          541398 472478 610318
## Apr 2021          542973 472130 613816
## May 2021          544555 471839 617270
## Jun 2021          545888 471348 620429
## Jul 2021          547448 471126 623770
## Aug 2021          547527 469464 625589
## Sep 2021          552322 472557 632088
## Oct 2021          553306 471873 634739
## Nov 2021          555035 471295 638775
## Dec 2021          557177 471192 643163
## Jan 2022          556021 467848 644195
```

```
## Feb 2022          556368 466059 646677
## Mar 2022          558075 465680 650470
## Apr 2022          559849 465415 654284
## May 2022          561235 464804 657666
## Jun 2022          562857 464469 661244
## Jul 2022          564165 463860 664471
## Aug 2022          564256 462068 666443
## Sep 2022          569328 465293 673364
## Oct 2022          570528 464677 676379
## Nov 2022          572238 463974 680501
## Dec 2022          574471 463848 685095
## Jan 2023          573774 460841 686708
## Feb 2023          573843 458645 689041
## Mar 2023          575613 458194 693031
## Apr 2023          577283 457686 696881
## May 2023          578596 456858 700334
## Jun 2023          579869 456028 703711
## Jul 2023          581394 455485 707304
## Aug 2023          581439 453495 709383
## Sep 2023          586888 456941 716835
## Oct 2023          587997 456077 719916
## Nov 2023          589715 455183 724247
## Dec 2023          591734 454638 728829
## Jan 2024          590739 451128 730350
## Feb 2024          590867 448785 732950
## Mar 2024          592828 448316 737340
## Apr 2024          594485 447584 741386
## May 2024          595926 446674 745177
## Jun 2024          597310 445744 748875
## Jul 2024          598795 444950 752641
## Aug 2024          598865 442774 754957
## Sep 2024          603954 445649 762260
## Oct 2024          605034 444545 765524
## Nov 2024          606755 443538 769972
## Dec 2024          608877 442977 774777
## Jan 2025          607890 439350 776430
## Feb 2025          608093 436954 779232
## Mar 2025          609903 436203 783603
## Apr 2025          611611 435388 787834
## May 2025          612998 434287 791709
## Jun 2025          614451 433287 795616
## Jul 2025          615875 432290 799460
## Aug 2025          615947 429972 801921
## Sep 2025          621118 432784 809451
## Oct 2025          622254 431591 812917
## Nov 2025          623969 430459 817480
## Dec 2025          626112 429795 822428
## Jan 2026          625241 426158 824324
## Feb 2026          625371 423559 827183
## Mar 2026          627201 422697 831706
## Apr 2026          628882 421720 836043
## May 2026          630252 420466 840037
```

```
## Jun 2026          631614 419238 843991
## Jul 2026          633095 418158 848031
## Aug 2026          633155 415688 850621
## Sep 2026          638419 418452 858386
## Oct 2026          639530 417090 861970
## Nov 2026          641248 415826 866671
## Dec 2026          643335 414969 871701
## Jan 2027          642385 411112 873658
## Feb 2027          642532 408389 876675
## Mar 2027          644411 407433 881389
## Apr 2027          646089 406309 885869
## May 2027          647491 404942 890041
## Jun 2027          648885 403598 894173
## Jul 2027          650354 402358 898349
## Aug 2027          650421 399746 901095
## Sep 2027          655590 402265 908915
## Oct 2027          656695 400747 912643
```

```
# Interpretation: Nov, 2017: The point forecast is 488,272. the Lo 95 and high 95 is the confide
nce level, if it is low, it will be 481,236, if high, it  will be 495,309. It is safe to go with
the minimum.

plot(data_forecast, main = "Forecasted Tractor Sales for the next 10 years", col="red")
```

Forecasted Tractor Sales for the next 10 years
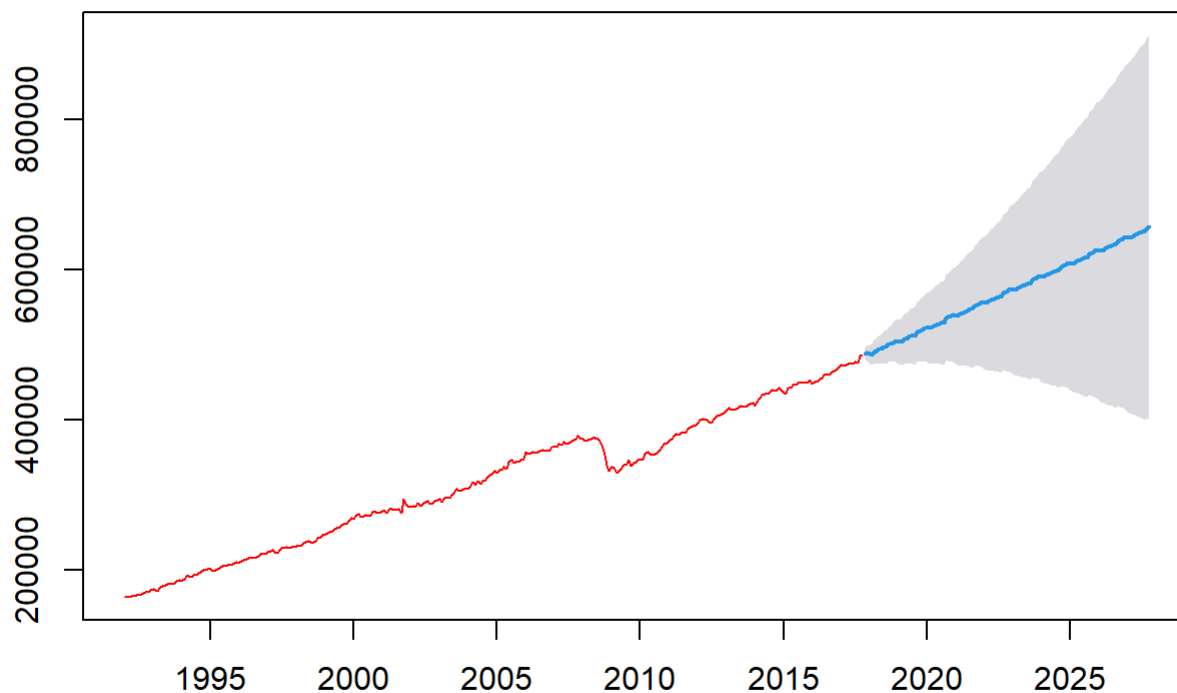
```
#  Interpretation: retail sales will keep growing (a trend) and also captures the seasonality.
```

Validation of the model

```
Box.test(data_forecast$residuals, lag =12, type = "Ljung-Box")
```

```
##
##   Box-Ljung test
##
## data:   data_forecast$residuals
## X-squared = 23, df = 12, p-value = 0.03
```

```
# Interpretation: For the Box-Ljung test, p value is less than 0.5


print(summary(data_forecast))
```

```
##
## Forecast method: ARIMA(0,1,0)(2,1,0)[12]
##
## Model Information:
## Series: data_ts
## ARIMA(0,1,0)(2,1,0)[12]
##
## Coefficients:
##          sar1     sar2
##        -0.656   -0.409
## s.e.    0.053    0.052
##
## sigma^2 = 12890146:  log likelihood = -2855
## AIC=5717    AICc=5717    BIC=5728
##
## Error measures:
##                   ME RMSE  MAE      MPE    MAPE    MASE      ACF1
## Training set 39.73 3502 2493 0.009343 0.7799 0.1613 -0.02371
##
## Forecasts:
##           Point Forecast  Lo 95  Hi 95
## Nov 2017          488272 481236 495309
## Dec 2017          489076 479124 499028
## Jan 2018          487407 475219 499595
## Feb 2018          487104 473031 501178
## Mar 2018          490583 474848 506318
## Apr 2018          491832 474595 509069
## May 2018          493938 475320 512556
## Jun 2018          495032 475129 514935
## Jul 2018          496903 475792 518013
## Aug 2018          497010 474757 519262
## Sep 2018          500742 477403 524080
## Oct 2018          501347 476970 525723
## Nov 2018          503109 476961 529257
## Dec 2018          505297 477490 533104
## Jan 2019          503459 474086 532831
## Feb 2019          504361 473502 535219
## Mar 2019          505704 473427 537980
## Apr 2019          507726 474092 541360
## May 2019          509126 474186 544066
## Jun 2019          511401 475203 547599
## Jul 2019          512270 474856 549684
## Aug 2019          512433 473842 551025
## Sep 2019          517081 477347 556816
## Oct 2019          518519 477674 559364
## Nov 2019          520207 477626 562788
## Dec 2019          522802 478553 567051
## Jan 2020          522765 476909 568621
## Feb 2020          522612 475203 570021
## Mar 2020          524129 475217 573042
## Apr 2020          525770 475399 576141
## May 2020          526860 475071 578648
```

```
## Jun 2020          527802 474634 580971
## Jul 2020          529489 474975 584002
## Aug 2020          529474 473648 585300
## Sep 2020          535635 478527 592743
## Oct 2020          536743 478381 595105
## Nov 2020          538462 477841 599083
## Dec 2020          540225 477426 603024
## Jan 2021          539076 474173 603980
## Feb 2021          539123 472181 606065
## Mar 2021          541398 472478 610318
## Apr 2021          542973 472130 613816
## May 2021          544555 471839 617270
## Jun 2021          545888 471348 620429
## Jul 2021          547448 471126 623770
## Aug 2021          547527 469464 625589
## Sep 2021          552322 472557 632088
## Oct 2021          553306 471873 634739
## Nov 2021          555035 471295 638775
## Dec 2021          557177 471192 643163
## Jan 2022          556021 467848 644195
## Feb 2022          556368 466059 646677
## Mar 2022          558075 465680 650470
## Apr 2022          559849 465415 654284
## May 2022          561235 464804 657666
## Jun 2022          562857 464469 661244
## Jul 2022          564165 463860 664471
## Aug 2022          564256 462068 666443
## Sep 2022          569328 465293 673364
## Oct 2022          570528 464677 676379
## Nov 2022          572238 463974 680501
## Dec 2022          574471 463848 685095
## Jan 2023          573774 460841 686708
## Feb 2023          573843 458645 689041
## Mar 2023          575613 458194 693031
## Apr 2023          577283 457686 696881
## May 2023          578596 456858 700334
## Jun 2023          579869 456028 703711
## Jul 2023          581394 455485 707304
## Aug 2023          581439 453495 709383
## Sep 2023          586888 456941 716835
## Oct 2023          587997 456077 719916
## Nov 2023          589715 455183 724247
## Dec 2023          591734 454638 728829
## Jan 2024          590739 451128 730350
## Feb 2024          590867 448785 732950
## Mar 2024          592828 448316 737340
## Apr 2024          594485 447584 741386
## May 2024          595926 446674 745177
## Jun 2024          597310 445744 748875
## Jul 2024          598795 444950 752641
## Aug 2024          598865 442774 754957
## Sep 2024          603954 445649 762260
```

```
## Oct 2024          605034 444545 765524
## Nov 2024          606755 443538 769972
## Dec 2024          608877 442977 774777
## Jan 2025          607890 439350 776430
## Feb 2025          608093 436954 779232
## Mar 2025          609903 436203 783603
## Apr 2025          611611 435388 787834
## May 2025          612998 434287 791709
## Jun 2025          614451 433287 795616
## Jul 2025          615875 432290 799460
## Aug 2025          615947 429972 801921
## Sep 2025          621118 432784 809451
## Oct 2025          622254 431591 812917
## Nov 2025          623969 430459 817480
## Dec 2025          626112 429795 822428
## Jan 2026          625241 426158 824324
## Feb 2026          625371 423559 827183
## Mar 2026          627201 422697 831706
## Apr 2026          628882 421720 836043
## May 2026          630252 420466 840037
## Jun 2026          631614 419238 843991
## Jul 2026          633095 418158 848031
## Aug 2026          633155 415688 850621
## Sep 2026          638419 418452 858386
## Oct 2026          639530 417090 861970
## Nov 2026          641248 415826 866671
## Dec 2026          643335 414969 871701
## Jan 2027          642385 411112 873658
## Feb 2027          642532 408389 876675
## Mar 2027          644411 407433 881389
## Apr 2027          646089 406309 885869
## May 2027          647491 404942 890041
## Jun 2027          648885 403598 894173
## Jul 2027          650354 402358 898349
## Aug 2027          650421 399746 901095
## Sep 2027          655590 402265 908915
## Oct 2027          656695 400747 912643
```

```
checkresiduals(data_forecast)
```

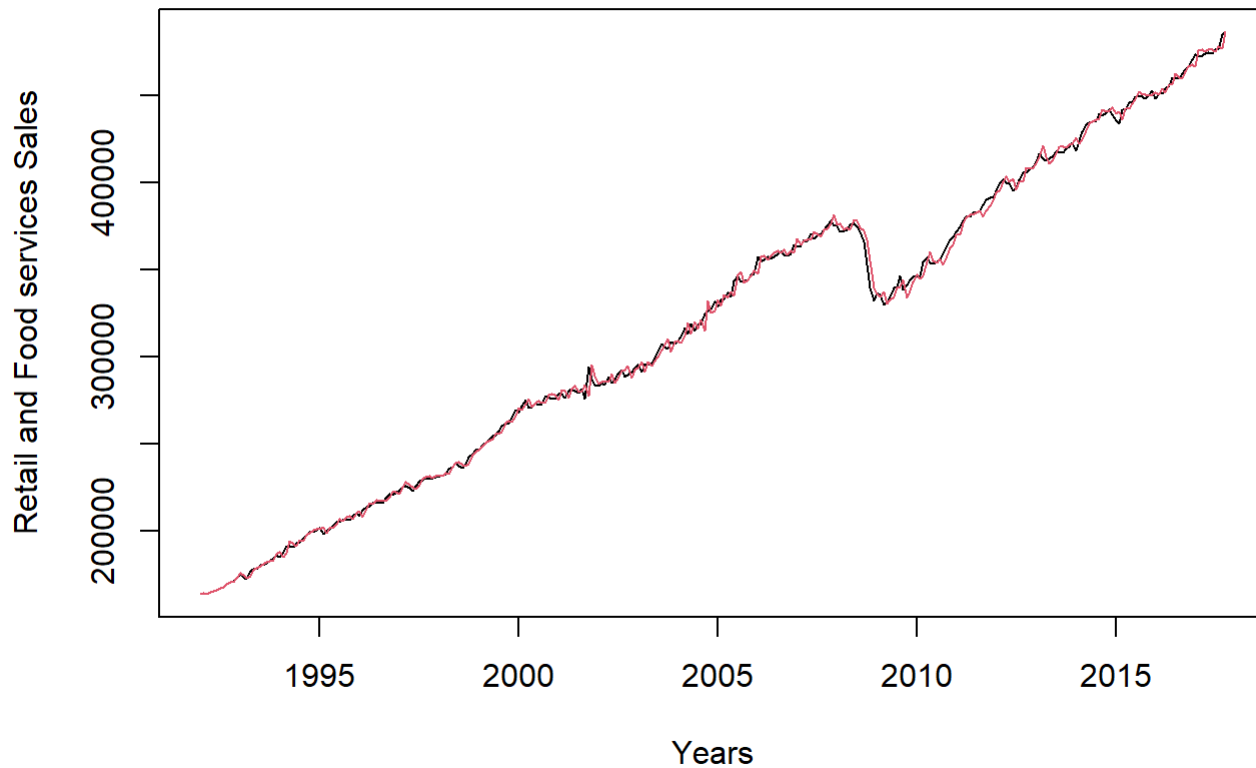## Residuals from ARIMA(0,1,0)(2,1,0)[12]
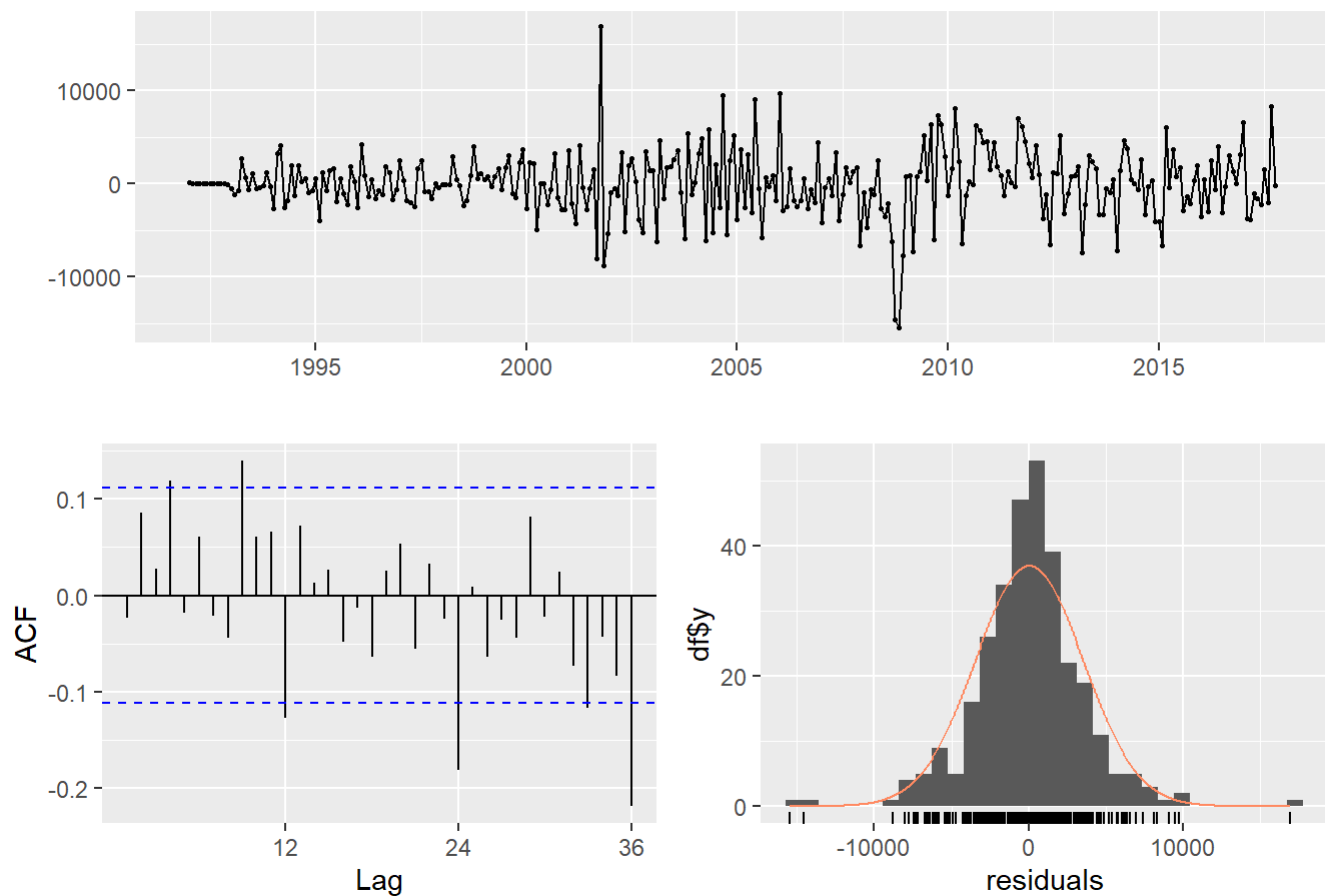

```
##
##   Ljung-Box test
##
## data:  Residuals from ARIMA(0,1,0)(2,1,0)[12]
## Q* = 41, df = 22, p-value = 0.007
##
## Model df: 2.   Total lags used: 24
```

Plotting real vs Fitted Values

```
ts.plot(new_arima$x, new_arima$fitted, col=1:2, gpars = list(xlab = "Years", ylab="Retail and Fo
od services Sales", main= "Real vs Fitted Values"))
```

Real vs Fitted Values

Recommendation and Conclusion:

Retail and Food services Sales will keep growing upward (a trend) and it also captures the seasonality and ARIMA model fits the best according to our end sample statistics (standard deviation: 3590, aic=5717, MAPE: on the average of 7.7% away from the truth) and I use to form forecast.