Time Series Modeling

We will begin loading our selected packages into R.

library(tidyverse)

## Warning: package 'tidyverse' was built under R version 4.3.3

## Warning: package 'ggplot2' was built under R version 4.3.3

## Warning: package 'lubridate' was built under R version 4.3.3

## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──  
## ✔ dplyr 1.1.2 ✔ readr 2.1.4  
## ✔ forcats 1.0.0 ✔ stringr 1.5.0  
## ✔ ggplot2 3.5.0 ✔ tibble 3.2.1  
## ✔ lubridate 1.9.3 ✔ tidyr 1.3.0  
## ✔ purrr 1.0.1   
## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()  
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(timeSeries)

## Warning: package 'timeSeries' was built under R version 4.3.3

## Loading required package: timeDate

## Warning: package 'timeDate' was built under R version 4.3.2

##   
## Attaching package: 'timeSeries'  
##   
## The following object is masked from 'package:dplyr':  
##   
## lag  
##   
## The following objects are masked from 'package:graphics':  
##   
## lines, points

library(fable)

## Warning: package 'fable' was built under R version 4.3.3

## Loading required package: fabletools

## Warning: package 'fabletools' was built under R version 4.3.3

## Registered S3 method overwritten by 'tsibble':  
## method from   
## as\_tibble.grouped\_df dplyr

library(tseries)

## Warning: package 'tseries' was built under R version 4.3.3

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

library(TSstudio)

## Warning: package 'TSstudio' was built under R version 4.3.3

library(forecast)

## Warning: package 'forecast' was built under R version 4.3.3

library(astsa)

## Warning: package 'astsa' was built under R version 4.3.2

##   
## Attaching package: 'astsa'  
##   
## The following object is masked from 'package:forecast':  
##   
## gas

###Importing our csv data set into R environment and inspecting it.

wgu\_data <- read\_csv("C:/Users/Tyler Bier/OneDrive/WGU - MSDA/D213- Advanced Data Analytics/Task1- Time series modeling/medical\_time\_series .csv")

## Rows: 731 Columns: 2  
## ── Column specification ────────────────────────────────────────────────────────  
## Delimiter: ","  
## dbl (2): Day, Revenue  
##   
## ℹ Use `spec()` to retrieve the full column specification for this data.  
## ℹ Specify the column types or set `show\_col\_types = FALSE` to quiet this message.

summary(wgu\_data)

## Day Revenue   
## Min. : 1.0 Min. :-4.423   
## 1st Qu.:183.5 1st Qu.:11.122   
## Median :366.0 Median :15.952   
## Mean :366.0 Mean :14.180   
## 3rd Qu.:548.5 3rd Qu.:19.294   
## Max. :731.0 Max. :24.792

head(wgu\_data)

## # A tibble: 6 × 2  
## Day Revenue  
## <dbl> <dbl>  
## 1 1 0   
## 2 2 -0.292  
## 3 3 -0.328  
## 4 4 -0.340  
## 5 5 -0.125  
## 6 6 -0.492

is.data.frame(wgu\_data)

## [1] TRUE

glimpse(wgu\_data)

## Rows: 731  
## Columns: 2  
## $ Day <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,…  
## $ Revenue <dbl> 0.0000000, -0.2923555, -0.3277718, -0.3399871, -0.1248875, -0.…

###Beginning the data cleaning process. Looking any missing values, Null values, or any duplicated items.

colSums(is.na(wgu\_data))

## Day Revenue   
## 0 0

is\_null(wgu\_data)

## [1] FALSE

anyDuplicated(wgu\_data)

## [1] 0

###Data is clean. Plotting a line graph for PA part C1. Must first convert data set to a vector format and then time series format.

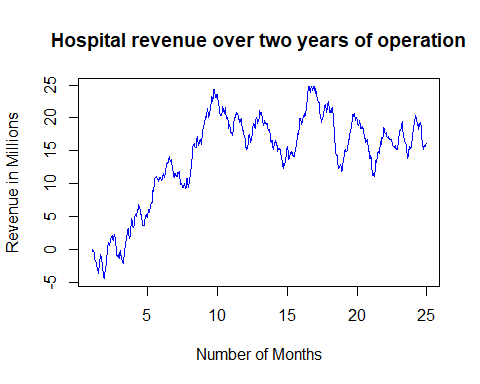
wgu\_data\_vector <- wgu\_data[['Revenue']]  
is.vector(wgu\_data\_vector)

## [1] TRUE

timeSer <- ts(wgu\_data\_vector, frequency= 731/24)  
is.ts(timeSer)

## [1] TRUE

plot(timeSer, xlab ="Number of Months", ylab= "Revenue in Millions", type ="l", main= "Hospital revenue over two years of operation", col = "blue")



print(timeSer)

## Time Series:  
## Start = 1   
## End = 24.9671682626539   
## Frequency = 30.4583333333333   
## [1] 0.00000000 -0.29235551 -0.32777180 -0.33998712 -0.12488752 -0.49158956  
## [7] -1.25524981 -1.89627889 -1.74725938 -2.12955767 -2.15142187 -3.22863700  
## [13] -2.82261611 -3.60971276 -3.39887512 -2.86742462 -2.71460692 -2.02108399  
## [19] -1.12601417 -0.84554515 -1.18784907 -1.59336888 -2.23363357 -2.98296814  
## [25] -3.74967618 -4.06831795 -4.17291175 -4.42329870 -3.77323732 -3.13036593  
## [31] -3.06699738 -2.22210903 -1.35465079 -0.41589860 0.08884823 0.98681089  
## [37] 1.07208612 0.57528878 0.77847588 0.73196193 1.26740763 1.27765111  
## [43] 1.92965323 1.88988029 2.11756586 1.50808259 1.36342093 1.57392010  
## [49] 2.23015415 2.30021882 2.19261817 1.68846471 0.97280056 0.11118353  
## [55] -0.76091828 -1.13651353 -1.00924333 -0.79661916 -1.05952317 -1.35656447  
## [61] -0.82054623 -0.21037409 -0.71997908 -0.97557157 -0.89799749 -1.48208720  
## [67] -1.71853182 -1.94498419 -2.08163125 -1.67759883 -0.85702750 0.13807808  
## [73] 0.29225176 0.71532475 0.99985401 1.38247323 1.77940671 2.52737328  
## [79] 3.03581311 3.16281552 2.56744451 1.69993096 1.61972529 2.15744872  
## [85] 3.33619129 3.82394944 4.29542606 4.64672718 4.17809274 3.51394046  
## [91] 3.41236614 3.31075785 3.82166659 4.63043983 5.32676923 5.22589066  
## [97] 5.04315472 5.14507113 5.22007126 5.85037678 6.09648893 6.12546089  
## [103] 6.82309241 6.44069962 6.39062265 5.86570152 5.35423497 5.27378511  
## [109] 5.05744971 4.83478546 4.14051638 3.56362351 3.61658457 3.69835767  
## [115] 3.62170725 3.93793958 5.17170572 5.20390162 5.36131373 4.98890073  
## [121] 4.77044415 4.90036123 5.05323921 6.00657143 5.93032488 5.71543766  
## [127] 5.62903599 6.48986248 6.71276799 7.19705927 7.03616688 7.10041120  
## [133] 7.97131468 8.96532868 8.80208341 9.19888334 9.64799724 10.64242361  
## [139] 10.87305828 10.86136081 11.10909178 11.15183669 10.57215633 10.71685029  
## [145] 10.37960890 10.60628747 10.60806877 10.63457878 10.89393966 10.82687488  
## [151] 10.95761761 10.54065737 10.45554673 10.59949748 11.04588172 11.52234191  
## [157] 11.34734423 11.57505258 10.87052261 10.91859971 11.72891120 12.35524380  
## [163] 12.50978326 13.09759974 13.06058006 13.15472692 13.21953178 13.70950155  
## [169] 14.03037405 14.09952605 13.81021580 13.53283397 13.34737095 13.64552297  
## [175] 13.05270212 12.54338309 12.51023704 11.49645527 11.06400360 10.91348824  
## [181] 11.02021545 11.59504505 11.52909833 11.21456868 11.05443450 11.24443203  
## [187] 11.12431599 11.67838468 11.53165810 11.62863107 11.28259614 11.80001114  
## [193] 10.98934740 10.50358016 9.86148569 10.03416379 10.08627842 9.55311562  
## [199] 9.41233969 9.74748564 9.44269761 9.94101458 9.89509820 9.53174970  
## [205] 9.24862447 9.23239282 9.37147065 10.70447637 10.80789525 10.23711276  
## [211] 9.38616295 9.59653492 10.26465563 10.52707705 11.31493865 12.11628343  
## [217] 12.01820955 12.38268926 13.28355365 14.27765592 15.33083155 15.91018951  
## [223] 15.92287096 16.04580246 15.71461819 15.52612490 15.53723932 15.53854650  
## [229] 16.54513094 16.71738749 17.15379376 16.87350767 16.01998436 15.74730154  
## [235] 16.17500206 16.43686264 16.72761626 16.68317242 16.05986155 15.95183003  
## [241] 16.26091436 17.51151503 18.12423800 18.39935094 18.60895766 19.25965933  
## [247] 19.39897911 19.81679130 20.17202384 20.02925640 20.48237962 21.24176639  
## [253] 21.44107894 21.32805991 20.52548866 19.99965124 20.30960671 20.76375889  
## [259] 21.18108986 21.73002354 22.38507705 23.27109385 23.10810298 22.80780801  
## [265] 22.45721597 23.14323958 24.25454098 24.39029659 24.24192076 23.31085247  
## [271] 23.11125888 23.10119411 23.55154135 23.47918839 23.58015145 23.09946413  
## [277] 22.50202793 22.25599684 21.59646221 20.80239262 20.50511703 20.29541529  
## [283] 20.38180606 20.52471876 20.77457048 21.75312933 21.40841468 21.17654981  
## [289] 21.08531565 20.73978259 20.79254110 21.60332299 20.78927347 20.17024472  
## [295] 19.86818033 19.77301482 20.01425707 19.52097882 18.43814072 18.64671159  
## [301] 18.95051579 18.83960393 18.31354062 17.79698810 17.81044493 17.68630952  
## [307] 17.49616085 17.34578868 18.23251653 19.42845811 19.57832686 19.73615187  
## [313] 20.13527699 20.08228763 20.50900464 20.58125915 20.77965065 20.50631922  
## [319] 20.59477812 20.27971009 19.94044816 19.52679262 19.69555778 19.34297164  
## [325] 19.42067267 19.78043554 19.87482205 19.07356375 18.60755878 18.05845959  
## [331] 18.04120951 17.79178940 17.23307158 17.26777341 16.77847659 16.19784221  
## [337] 15.46408174 15.44200193 15.18524849 15.37956777 15.29980182 16.43135418  
## [343] 17.39165351 17.41567218 17.07282932 16.90275916 16.42152911 16.27720408  
## [349] 16.63851400 16.66854395 17.59501517 18.40240253 18.93028158 19.07474653  
## [355] 18.93172244 18.52257206 18.35132530 18.83294272 19.61689989 19.96263596  
## [361] 20.01570800 19.56631950 19.13766496 19.41546546 19.41141311 20.27007344  
## [367] 21.05455237 20.80103975 20.49621756 20.33229330 20.76331504 20.64435316  
## [373] 20.00703063 19.66406306 18.85381876 19.06842115 19.12768412 19.62877239  
## [379] 19.32234915 19.11647870 19.12648854 18.98216135 19.10488759 19.14934300  
## [385] 18.48729895 18.04310885 18.17420210 18.18266181 17.93060759 17.50659816  
## [391] 16.62133727 16.24655262 16.58335590 16.54067996 16.41540223 15.83245152  
## [397] 15.18698149 15.53459058 15.94869702 16.28489266 16.21923010 16.63014600  
## [403] 16.07062587 15.83854691 15.74525264 14.86282361 15.11712332 15.23537670  
## [409] 15.33383198 15.32809010 15.21556010 15.13816135 14.62520662 14.16896250  
## [415] 14.03718789 13.20456728 12.87170405 12.37203938 13.00860339 12.34727803  
## [421] 12.85895013 12.78861272 13.44318655 13.85685512 14.22030460 15.01732959  
## [427] 15.63499339 15.20822077 15.11372339 14.49483878 13.68868211 13.90632746  
## [433] 13.75502130 14.72506461 14.37025704 14.55664976 14.82437591 14.66020382  
## [439] 14.32523093 14.35321911 14.11550898 14.23111643 14.07643074 14.47678687  
## [445] 14.97897336 15.33220256 15.78830544 16.32930792 17.02116113 17.64796359  
## [451] 17.45235266 17.67754922 18.53468087 19.28679632 19.92268506 19.94592829  
## [457] 19.88401812 19.37368176 18.96268644 19.30021638 19.90994029 19.98600966  
## [463] 20.15257227 20.65639748 20.24764509 20.35840064 20.40599677 20.78899362  
## [469] 21.32369036 21.91210454 22.76537315 23.65651901 24.28427461 24.71991579  
## [475] 24.70219109 24.34441654 23.90215996 24.28728824 24.36337379 24.59267678  
## [481] 24.78648660 24.40179138 24.22407458 24.50485315 24.73754444 24.22381250  
## [487] 24.79224925 24.50223685 24.32510579 23.68528079 23.96667888 23.37814612  
## [493] 22.97179742 22.77963895 22.38191492 22.45540878 22.30188749 20.93709085  
## [499] 20.22934582 20.31748124 19.38642381 19.34715037 19.41952252 19.74993909  
## [505] 19.88512288 20.39561487 20.88758605 21.11584642 21.70557599 21.98160523  
## [511] 21.63929070 21.45086723 21.21678023 20.84265813 21.39243097 22.07355692  
## [517] 22.55416754 22.04989146 21.52657776 20.84716909 20.89004436 20.95616966  
## [523] 21.36993978 20.85181211 20.82123696 21.54594731 20.97035542 20.61429967  
## [529] 19.18423803 18.23379502 17.01067089 15.52168674 14.68280520 14.26711828  
## [535] 14.25716100 14.33526130 13.99599107 13.34591973 12.22730918 12.33249832  
## [541] 12.37732752 12.62458427 12.81438984 12.97291726 12.56518370 11.87861291  
## [547] 12.05844579 12.18031969 12.85321650 13.43787156 13.87645903 14.30220212  
## [553] 15.06566591 15.21174805 14.93010045 14.88542803 14.81785462 15.07030357  
## [559] 15.54372397 16.08853531 16.69569590 16.66404928 16.73611598 17.60434655  
## [565] 17.78580525 18.11695901 18.31833304 19.15812589 19.56843926 20.45844332  
## [571] 20.43089703 20.16155368 20.33122453 20.69256668 20.16570973 20.10815508  
## [577] 19.53625416 19.86755397 20.02259050 19.78263543 19.08826542 18.80550091  
## [583] 18.91023263 19.18608936 19.31273398 19.57672475 18.98803475 18.43760771  
## [589] 18.51908507 18.37249848 18.40125387 18.64812932 18.33325378 17.69431401  
## [595] 17.46511988 16.93402572 17.23473672 16.84142672 16.22910638 16.40851998  
## [601] 16.63257795 16.67862794 16.25484481 15.45111819 14.83145352 14.85477225  
## [607] 14.26352674 13.82316571 13.85292416 14.30303825 13.81404793 12.53492808  
## [613] 11.59997052 11.18296694 11.30992176 11.56385028 11.11916768 11.28501839  
## [619] 12.34642905 13.08351696 13.53518778 13.21823281 13.40939508 14.06523756  
## [625] 14.71663889 14.84117658 14.67312028 14.60045465 15.02646456 16.02914971  
## [631] 16.45267281 16.11553884 15.98378420 17.04559138 17.03249392 16.86755462  
## [637] 17.38269453 18.53401643 18.42636819 17.74886725 17.65585117 17.65435043  
## [643] 17.74334287 17.41515672 17.35849569 17.03394954 17.02397361 17.12924705  
## [649] 16.85215536 16.87632056 16.74196846 16.65679565 16.77803414 16.72572860  
## [655] 16.41141682 16.68460581 16.05763027 15.83582485 15.62435873 15.58215608  
## [661] 15.44953699 15.54358000 15.73518259 15.32726854 15.29212973 15.20409098  
## [667] 15.28867524 15.21272483 15.56314234 16.29417008 16.64104597 17.74169248  
## [673] 18.05209520 18.07906540 18.19260356 18.45640064 18.94372536 19.43926174  
## [679] 19.41508318 18.44808858 17.32676713 16.96580444 16.83548422 16.62847592  
## [685] 16.11429133 16.12943604 15.97647760 15.00198842 14.27435845 13.79413971  
## [691] 14.32249043 14.08876727 14.90497801 15.61118508 15.25722325 15.44995913  
## [697] 15.30104445 15.53990358 16.05930024 16.69294392 17.83743995 17.97049828  
## [703] 18.34314806 18.76031022 19.08031732 19.37859058 20.07618154 20.30713669  
## [709] 20.03550478 19.75000881 18.92506696 18.80368721 18.97848606 18.69402609  
## [715] 18.18418878 18.87576548 18.96851930 19.37214904 19.33828833 18.51265351  
## [721] 17.33376752 16.15511086 15.98145875 15.24621933 15.69321833 15.75474857  
## [727] 15.72205587 15.86582153 15.70898774 15.82286745 16.06942948

####Evalutating stationary using the ADFuler Test

adf.test(timeSer)

##   
## Augmented Dickey-Fuller Test  
##   
## data: timeSer  
## Dickey-Fuller = -2.5906, Lag order = 9, p-value = 0.3283  
## alternative hypothesis: stationary

####p-value of ADFuler test is too high to reject null hypothesis. Will difference timeSer data and then run test again.

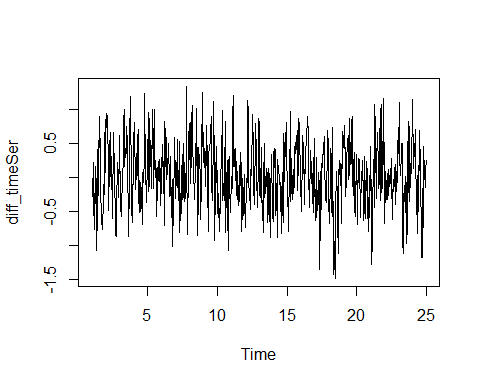
diff\_timeSer <- diff(timeSer)

adf.test(diff\_timeSer)

## Warning in adf.test(diff\_timeSer): p-value smaller than printed p-value

##   
## Augmented Dickey-Fuller Test  
##   
## data: diff\_timeSer  
## Dickey-Fuller = -7.2794, Lag order = 8, p-value = 0.01  
## alternative hypothesis: stationary

plot(diff\_timeSer)



###With this p-value less than 0.05, we can reject the null hypthothesis. Our data is now stationary. Will have to account for nonstationary nature in auto-arima function later on. (x,1,x)

###Will now be splitting our differenced data into training and test splits. Aiming for 80/20 split.

Time\_split <- ts\_split(timeSer, sample.out = 146)  
train <- Time\_split$train  
test <- Time\_split$test  
  
length(Time\_split)

## [1] 2

length(train)

## [1] 585

length(test)

## [1] 146

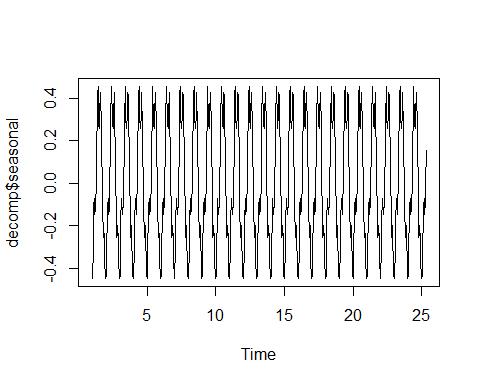
###Will now be providing copies of our cleaned data sets. ‘train’ and ‘test’, Will be using them for later model.

write.csv(train,"C:/Users/Tyler Bier/Desktop/D213 sets.csv")  
write.csv(test,"C:/Users/Tyler Bier/Desktop/D213 sets.csv")

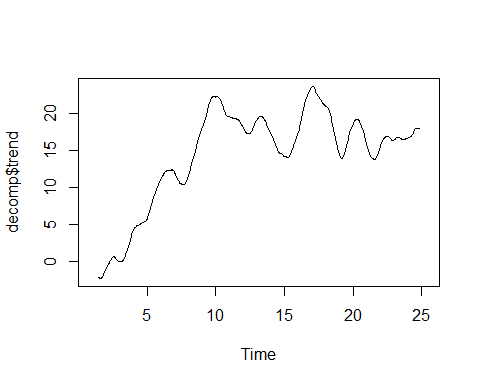
###Will now be analyzing the time series data with visualizations Part D1 in PA.

##Checking for seasonal component and trends with decomposition function.

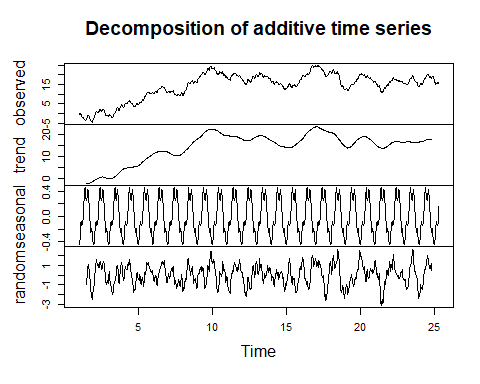
seasonality <- ts(wgu\_data$Revenue, frequency = 30)  
decomp <- decompose(seasonality)  
plot(decomp$seasonal)



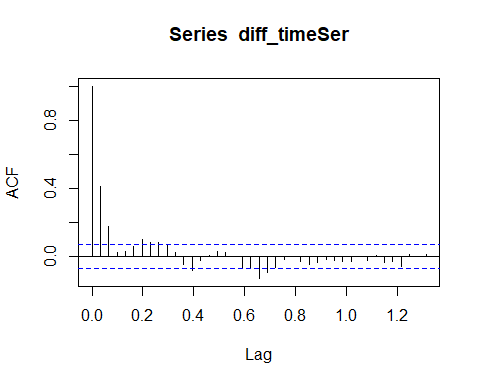
plot(decomp$trend)



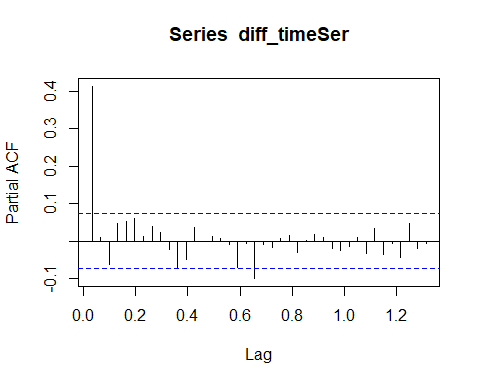
plot(decomp)

 ###Finding auto correlation with acf function and partial auto correlation on our time-series differenced data .

acf(diff\_timeSer, type = "correlation", plot = TRUE, lag.max = 40)

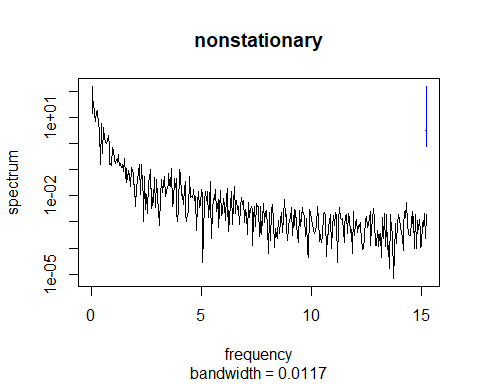


acf(diff\_timeSer, type = "partial", plot = TRUE, lag.max = 40)



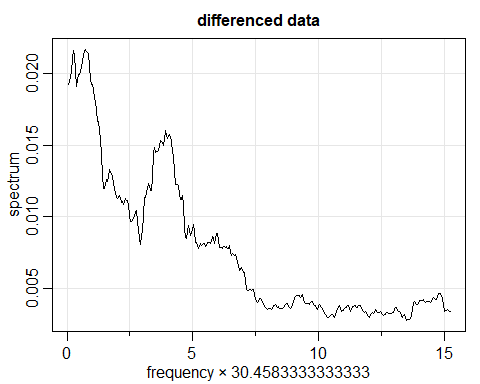
#### Finding spectral density, comparing both our differenced data and our original time series (Nonstationary) data.

spectrum(timeSer, main="nonstationary")



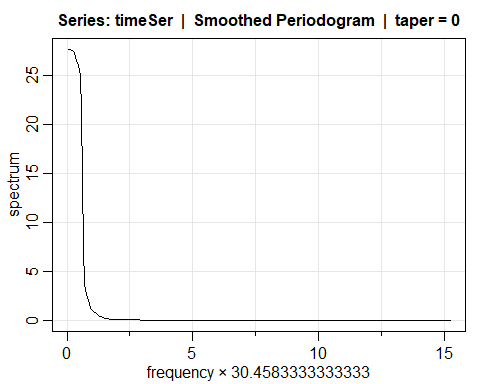
mvspec(diff\_timeSer, spans= 30, main="differenced data")

## Bandwidth: 1.239   
## Degrees of Freedom: 59.39



mvspec(timeSer, spans = 30)

## Bandwidth: 1.239   
## Degrees of Freedom: 59.47

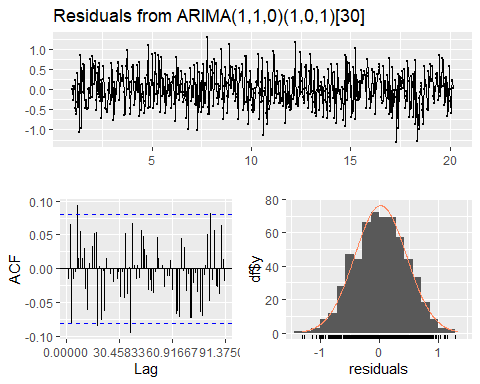


###Moving to part D2 in performance assessment. ###Will be using auto.arima () function to help determine best fit. Calling summary and checking residuals as well.

auto\_arima <- auto.arima(train, stationary = FALSE, allowdrift = TRUE, allowmean = TRUE)  
summary(auto\_arima)

## Series: train   
## ARIMA(1,1,0)(1,0,1)[30]   
##   
## Coefficients:  
## ar1 sar1 sma1  
## 0.4113 0.2674 -0.2574  
## s.e. 0.0378 2.2054 2.1799  
##   
## sigma^2 = 0.1957: log likelihood = -350.88  
## AIC=709.77 AICc=709.84 BIC=727.25  
##   
## Training set error measures:  
## ME RMSE MAE MPE MAPE MASE  
## Training set 0.01935062 0.4408162 0.356163 -0.2463411 8.80322 0.09731206  
## ACF1  
## Training set -0.01586027

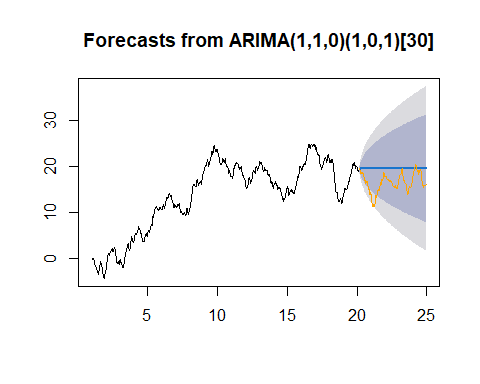
checkresiduals(auto\_arima)



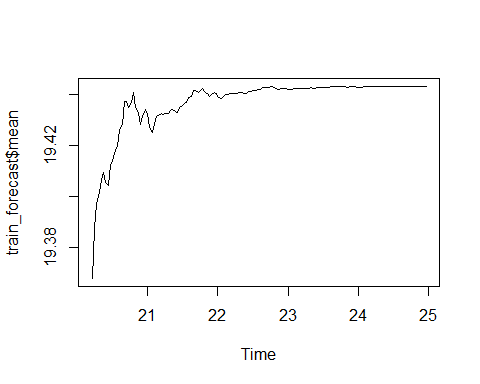
##   
## Ljung-Box test  
##   
## data: Residuals from ARIMA(1,1,0)(1,0,1)[30]  
## Q\* = 55.616, df = 57.917, p-value = 0.5614  
##   
## Model df: 3. Total lags used: 60.9166666666667

###Now performing a forecast based on auto.arima fitting as listed in part D3. 146 days selected to cover test data (146 days), will predict additional days later at 365 days.

train\_forecast <- forecast(auto\_arima, h=146)  
plot(train\_forecast)  
lines(test, col = "orange")



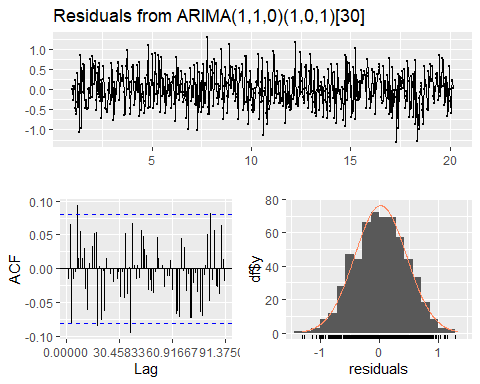
plot(train\_forecast$mean)



summary(train\_forecast)

##   
## Forecast method: ARIMA(1,1,0)(1,0,1)[30]  
##   
## Model Information:  
## Series: train   
## ARIMA(1,1,0)(1,0,1)[30]   
##   
## Coefficients:  
## ar1 sar1 sma1  
## 0.4113 0.2674 -0.2574  
## s.e. 0.0378 2.2054 2.1799  
##   
## sigma^2 = 0.1957: log likelihood = -350.88  
## AIC=709.77 AICc=709.84 BIC=727.25  
##   
## Error measures:  
## ME RMSE MAE MPE MAPE MASE  
## Training set 0.01935062 0.4408162 0.356163 -0.2463411 8.80322 0.09731206  
## ACF1  
## Training set -0.01586027  
##   
## Forecasts:  
## Point Forecast Lo 80 Hi 80 Lo 95 Hi 95  
## 20.20657 19.36765 18.800777 19.93452 18.500694 20.23460  
## 20.23940 19.38737 18.406894 20.36786 17.887858 20.88689  
## 20.27223 19.39718 18.069043 20.72531 17.365971 21.42839  
## 20.30506 19.40156 17.777136 21.02598 16.917219 21.88590  
## 20.33789 19.40626 17.523667 21.28885 16.527083 22.28543  
## 20.37073 19.40934 17.296923 21.52175 16.178679 22.63999  
## 20.40356 19.40556 17.084854 21.72627 15.856346 22.95478  
## 20.43639 19.40437 16.892148 21.91659 15.562258 23.24648  
## 20.46922 19.41236 16.722056 22.10266 15.297896 23.52682  
## 20.50205 19.41428 16.556907 22.27164 15.044307 23.78424  
## 20.53488 19.41809 16.402872 22.43331 14.806712 24.02947  
## 20.56772 19.41950 16.254290 22.58472 14.578727 24.26028  
## 20.60055 19.42649 16.118066 22.73491 14.366694 24.48628  
## 20.63338 19.42816 15.982476 22.87384 14.158441 24.69788  
## 20.66621 19.43760 15.859917 23.01528 13.966006 24.90919  
## 20.69904 19.43724 15.732257 23.14222 13.770957 25.10352  
## 20.73187 19.43499 15.606940 23.26305 13.580492 25.28949  
## 20.76471 19.43705 15.489758 23.38433 13.400190 25.47390  
## 20.79754 19.44092 15.377893 23.50394 13.227058 25.65478  
## 20.83037 19.43502 15.259461 23.61057 13.049057 25.82097  
## 20.86320 19.43304 15.147909 23.71817 12.879498 25.98658  
## 20.89603 19.42819 15.036212 23.82016 12.711242 26.14513  
## 20.92886 19.43141 14.935135 23.92769 12.554949 26.30788  
## 20.96170 19.43431 14.836092 24.03253 12.401943 26.46667  
## 20.99453 19.43286 14.734914 24.13080 12.247972 26.61775  
## 21.02736 19.42712 14.631520 24.22272 12.092883 26.76136  
## 21.06019 19.42533 14.534028 24.31664 11.944728 26.90594  
## 21.09302 19.42856 14.443391 24.41374 11.804399 27.05273  
## 21.12585 19.43136 14.354057 24.50867 11.666294 27.19643  
## 21.15869 19.43180 14.263998 24.59959 11.528332 27.33526  
## 21.19152 19.43273 14.174955 24.69050 11.391657 27.47380  
## 21.22435 19.43235 14.085687 24.77901 11.255335 27.60937  
## 21.25718 19.43265 13.998377 24.86691 11.121649 27.74364  
## 21.29001 19.43286 13.912306 24.95342 10.989901 27.87582  
## 21.32285 19.43372 13.828184 25.03926 10.860790 28.00666  
## 21.35568 19.43439 13.745117 25.12365 10.733400 28.13537  
## 21.38851 19.43331 13.661524 25.20510 10.606125 28.26050  
## 21.42134 19.43296 13.579821 25.28611 10.481354 28.38457  
## 21.45417 19.43509 13.501703 25.36847 10.360759 28.50942  
## 21.48700 19.43560 13.423040 25.44815 10.240184 28.63101  
## 21.51984 19.43661 13.345915 25.52731 10.121693 28.75154  
## 21.55267 19.43699 13.269140 25.60484 10.004076 28.86991  
## 21.58550 19.43886 13.194807 25.68291 9.889406 28.98831  
## 21.61833 19.43931 13.119973 25.75864 9.774720 29.10389  
## 21.65116 19.44183 13.048103 25.83556 9.663468 29.22019  
## 21.68399 19.44173 12.974468 25.90900 9.550904 29.33256  
## 21.71683 19.44113 12.901155 25.98111 9.439100 29.44317  
## 21.74966 19.44168 12.829792 26.05357 9.329668 29.55370  
## 21.78249 19.44272 12.759688 26.12575 9.221907 29.66353  
## 21.81532 19.44114 12.687721 26.19456 9.112677 29.76960  
## 21.84815 19.44061 12.617529 26.26369 9.005608 29.87561  
## 21.88098 19.43931 12.547273 26.33135 8.898847 29.97978  
## 21.91382 19.44018 12.479860 26.40049 8.795291 30.08506  
## 21.94665 19.44095 12.413021 26.46888 8.692661 30.18924  
## 21.97948 19.44056 12.345665 26.53546 8.589854 30.29127  
## 22.01231 19.43903 12.277789 26.60027 8.486858 30.39120  
## 22.04514 19.43855 12.211578 26.66552 8.385850 30.49125  
## 22.07798 19.43941 12.147301 26.73153 8.287090 30.59174  
## 22.11081 19.44016 12.083486 26.79684 8.189097 30.69123  
## 22.14364 19.44028 12.019599 26.86096 8.091329 30.78923  
## 22.17647 19.44053 11.956197 26.92486 7.994231 30.88682  
## 22.20930 19.44043 11.892899 26.98795 7.897479 30.98337  
## 22.24213 19.44051 11.830273 27.05074 7.801660 31.07935  
## 22.27497 19.44056 11.768125 27.11300 7.706582 31.17454  
## 22.30780 19.44079 11.706645 27.17494 7.612434 31.26915  
## 22.34063 19.44097 11.645597 27.23634 7.518976 31.36296  
## 22.37346 19.44068 11.584562 27.29680 7.425782 31.45558  
## 22.40629 19.44059 11.524186 27.35699 7.333495 31.54769  
## 22.43912 19.44116 11.464927 27.41739 7.242566 31.63975  
## 22.47196 19.44129 11.405682 27.47691 7.151885 31.73070  
## 22.50479 19.44157 11.347008 27.53613 7.062007 31.82113  
## 22.53762 19.44167 11.288589 27.59475 6.972609 31.91073  
## 22.57045 19.44217 11.230985 27.65335 6.884248 32.00009  
## 22.60328 19.44229 11.173410 27.71116 6.796131 32.08844  
## 22.63611 19.44296 11.116790 27.76913 6.709181 32.17674  
## 22.66895 19.44294 11.059861 27.82601 6.622129 32.26374  
## 22.70178 19.44277 11.003180 27.88237 6.535529 32.35002  
## 22.73461 19.44292 10.947183 27.93866 6.449811 32.43603  
## 22.76744 19.44320 10.891685 27.99471 6.364787 32.52161  
## 22.80027 19.44278 10.835849 28.04970 6.279617 32.60594  
## 22.83311 19.44264 10.780649 28.10462 6.195270 32.69000  
## 22.86594 19.44229 10.725591 28.15899 6.111250 32.77333  
## 22.89877 19.44252 10.671451 28.21359 6.028328 32.85671  
## 22.93160 19.44273 10.617623 28.26783 5.945896 32.93956  
## 22.96443 19.44262 10.563813 28.32143 5.863655 33.02159  
## 22.99726 19.44221 10.510019 28.37440 5.781602 33.10282  
## 23.03010 19.44208 10.456825 28.42734 5.700317 33.18385  
## 23.06293 19.44232 10.404302 28.48033 5.619866 33.26476  
## 23.09576 19.44252 10.352053 28.53298 5.539853 33.34518  
## 23.12859 19.44255 10.299937 28.58516 5.460131 33.42496  
## 23.16142 19.44261 10.248108 28.63712 5.380832 33.50439  
## 23.19425 19.44259 10.196460 28.68871 5.301856 33.58332  
## 23.22709 19.44261 10.145139 28.74008 5.223357 33.66186  
## 23.25992 19.44262 10.094091 28.79115 5.145278 33.73997  
## 23.29275 19.44268 10.043366 28.84200 5.067668 33.81770  
## 23.32558 19.44273 9.992899 28.89256 4.990460 33.89500  
## 23.35841 19.44265 9.942576 28.94273 4.913539 33.97177  
## 23.39124 19.44263 9.892570 28.99269 4.837073 34.04819  
## 23.42408 19.44278 9.843000 29.04256 4.761183 34.12438  
## 23.45691 19.44282 9.793571 29.09206 4.685569 34.20007  
## 23.48974 19.44289 9.744431 29.14135 4.610377 34.27540  
## 23.52257 19.44292 9.695493 29.19034 4.535519 34.35032  
## 23.55540 19.44305 9.646907 29.23920 4.461142 34.42496  
## 23.58824 19.44308 9.598460 29.28771 4.387032 34.49913  
## 23.62107 19.44326 9.550400 29.33613 4.313434 34.57309  
## 23.65390 19.44326 9.502386 29.38413 4.240006 34.64651  
## 23.68673 19.44321 9.454566 29.43186 4.166896 34.71953  
## 23.71956 19.44325 9.407057 29.47945 4.094215 34.79229  
## 23.75239 19.44333 9.359806 29.52685 4.021913 34.86474  
## 23.78523 19.44321 9.312590 29.57384 3.949761 34.93667  
## 23.81806 19.44318 9.265666 29.62069 3.878018 35.00834  
## 23.85089 19.44308 9.218903 29.66726 3.806548 35.07962  
## 23.88372 19.44315 9.172506 29.71378 3.735558 35.15073  
## 23.91655 19.44320 9.126312 29.76009 3.664881 35.22152  
## 23.94938 19.44317 9.080241 29.80610 3.594437 35.29191  
## 23.98222 19.44306 9.034292 29.85183 3.524222 35.36190  
## 24.01505 19.44303 8.988620 29.89744 3.454390 35.43167  
## 24.04788 19.44309 8.943242 29.94294 3.384958 35.50122  
## 24.08071 19.44314 8.898051 29.98824 3.315816 35.57047  
## 24.11354 19.44315 8.853009 30.03330 3.246925 35.63938  
## 24.14637 19.44317 8.808157 30.07818 3.178321 35.70802  
## 24.17921 19.44316 8.763464 30.12286 3.109973 35.77635  
## 24.21204 19.44317 8.718969 30.16737 3.041920 35.84442  
## 24.24487 19.44317 8.674655 30.21169 2.974146 35.91220  
## 24.27770 19.44319 8.630535 30.25584 2.906662 35.97972  
## 24.31053 19.44320 8.586591 30.29981 2.839448 36.04696  
## 24.34337 19.44318 8.542790 30.34357 2.772472 36.11389  
## 24.37620 19.44317 8.499179 30.38717 2.705777 36.18057  
## 24.40903 19.44322 8.455788 30.43064 2.639395 36.24704  
## 24.44186 19.44323 8.412537 30.47391 2.573243 36.31321  
## 24.47469 19.44324 8.369464 30.51703 2.507359 36.37913  
## 24.50752 19.44325 8.326547 30.55996 2.441719 36.44479  
## 24.54036 19.44329 8.283823 30.60275 2.376359 36.51022  
## 24.57319 19.44330 8.241235 30.64536 2.311222 36.57537  
## 24.60602 19.44334 8.198849 30.68784 2.246372 36.64032  
## 24.63885 19.44334 8.156571 30.73011 2.181715 36.70497  
## 24.67168 19.44333 8.114442 30.77222 2.117290 36.76937  
## 24.70451 19.44334 8.072491 30.81419 2.053126 36.83356  
## 24.73735 19.44336 8.030703 30.85602 1.989207 36.89752  
## 24.77018 19.44333 7.989018 30.89764 1.925471 36.96119  
## 24.80301 19.44332 7.947504 30.93914 1.861986 37.02466  
## 24.83584 19.44330 7.906125 30.98047 1.798715 37.08788  
## 24.86867 19.44331 7.864934 31.02169 1.735711 37.15091  
## 24.90150 19.44333 7.823889 31.06277 1.672929 37.21373  
## 24.93434 19.44332 7.782965 31.10368 1.610346 37.27629  
## 24.96717 19.44329 7.742163 31.14442 1.547959 37.33862

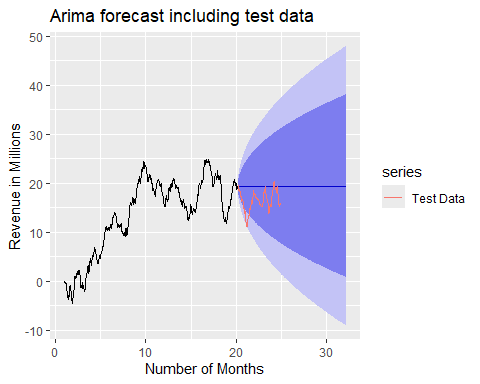
checkresiduals(train\_forecast)



##   
## Ljung-Box test  
##   
## data: Residuals from ARIMA(1,1,0)(1,0,1)[30]  
## Q\* = 55.616, df = 57.917, p-value = 0.5614  
##   
## Model df: 3. Total lags used: 60.9166666666667

##Forecast has been created. Plotting predictions at 365 days and placing it against original time series.

training\_forecast <- forecast(auto\_arima, h=365)  
autoplot(training\_forecast, main = "Arima forecast including test data", xlab= "Number of Months", ylab= "Revenue in Millions") +  
 autolayer(test, series = "Test Data")



###Creating comparative statistics between predicted and actual values. Train vs Test. Initially forecasting over test values.

train\_accuracy <- accuracy(train\_forecast)  
test\_accuracy <- accuracy(train\_forecast, test = test)  
print(train\_accuracy)

## ME RMSE MAE MPE MAPE MASE  
## Training set 0.01935062 0.4408162 0.356163 -0.2463411 8.80322 0.09731206  
## ACF1  
## Training set -0.01586027

print(test\_accuracy)

## ME RMSE MAE MPE MAPE MASE  
## Training set 0.2873543 0.5717045 0.5081273 -13.39041 20.09287 0.9601714  
## ACF1  
## Training set 0.3529327

###Computing Prediction intervals for train\_forecast and training\_forecast.

print(training\_forecast)

## Point Forecast Lo 80 Hi 80 Lo 95 Hi 95  
## 20.20657 19.36765 18.8007772 19.93452 18.500694326 20.23460  
## 20.23940 19.38737 18.4068936 20.36786 17.887858126 20.88689  
## 20.27223 19.39718 18.0690430 20.72531 17.365970740 21.42839  
## 20.30506 19.40156 17.7771362 21.02598 16.917219067 21.88590  
## 20.33789 19.40626 17.5236668 21.28885 16.527083361 22.28543  
## 20.37073 19.40934 17.2969231 21.52175 16.178679420 22.63999  
## 20.40356 19.40556 17.0848545 21.72627 15.856345507 22.95478  
## 20.43639 19.40437 16.8921481 21.91659 15.562258098 23.24648  
## 20.46922 19.41236 16.7220555 22.10266 15.297895852 23.52682  
## 20.50205 19.41428 16.5569068 22.27164 15.044307380 23.78424  
## 20.53488 19.41809 16.4028715 22.43331 14.806711831 24.02947  
## 20.56772 19.41950 16.2542900 22.58472 14.578726854 24.26028  
## 20.60055 19.42649 16.1180665 22.73491 14.366694146 24.48628  
## 20.63338 19.42816 15.9824756 22.87384 14.158441309 24.69788  
## 20.66621 19.43760 15.8599174 23.01528 13.966006474 24.90919  
## 20.69904 19.43724 15.7322568 23.14222 13.770957146 25.10352  
## 20.73187 19.43499 15.6069403 23.26305 13.580491619 25.28949  
## 20.76471 19.43705 15.4897579 23.38433 13.400190372 25.47390  
## 20.79754 19.44092 15.3778927 23.50394 13.227057766 25.65478  
## 20.83037 19.43502 15.2594613 23.61057 13.049056614 25.82097  
## 20.86320 19.43304 15.1479090 23.71817 12.879498281 25.98658  
## 20.89603 19.42819 15.0362124 23.82016 12.711242471 26.14513  
## 20.92886 19.43141 14.9351347 23.92769 12.554949044 26.30788  
## 20.96170 19.43431 14.8360916 24.03253 12.401942537 26.46667  
## 20.99453 19.43286 14.7349139 24.13080 12.247971951 26.61775  
## 21.02736 19.42712 14.6315203 24.22272 12.092883211 26.76136  
## 21.06019 19.42533 14.5340280 24.31664 11.944727646 26.90594  
## 21.09302 19.42856 14.4433907 24.41374 11.804399484 27.05273  
## 21.12585 19.43136 14.3540572 24.50867 11.666293653 27.19643  
## 21.15869 19.43180 14.2639985 24.59959 11.528331986 27.33526  
## 21.19152 19.43273 14.1749548 24.69050 11.391656887 27.47380  
## 21.22435 19.43235 14.0856874 24.77901 11.255335068 27.60937  
## 21.25718 19.43265 13.9983771 24.86691 11.121648939 27.74364  
## 21.29001 19.43286 13.9123063 24.95342 10.989901250 27.87582  
## 21.32285 19.43372 13.8281838 25.03926 10.860789924 28.00666  
## 21.35568 19.43439 13.7451171 25.12365 10.733400359 28.13537  
## 21.38851 19.43331 13.6615237 25.20510 10.606124562 28.26050  
## 21.42134 19.43296 13.5798207 25.28611 10.481353823 28.38457  
## 21.45417 19.43509 13.5017030 25.36847 10.360758608 28.50942  
## 21.48700 19.43560 13.4230397 25.44815 10.240184361 28.63101  
## 21.51984 19.43661 13.3459149 25.52731 10.121693335 28.75154  
## 21.55267 19.43699 13.2691397 25.60484 10.004075969 28.86991  
## 21.58550 19.43886 13.1948072 25.68291 9.889405812 28.98831  
## 21.61833 19.43931 13.1199730 25.75864 9.774720425 29.10389  
## 21.65116 19.44183 13.0481031 25.83556 9.663468470 29.22019  
## 21.68399 19.44173 12.9744680 25.90900 9.550904294 29.33256  
## 21.71683 19.44113 12.9011553 25.98111 9.439100183 29.44317  
## 21.74966 19.44168 12.8297916 26.05357 9.329668401 29.55370  
## 21.78249 19.44272 12.7596882 26.12575 9.221906535 29.66353  
## 21.81532 19.44114 12.6877210 26.19456 9.112677479 29.76960  
## 21.84815 19.44061 12.6175294 26.26369 9.005608426 29.87561  
## 21.88098 19.43931 12.5472725 26.33135 8.898846866 29.97978  
## 21.91382 19.44018 12.4798596 26.40049 8.795290824 30.08506  
## 21.94665 19.44095 12.4130214 26.46888 8.692660737 30.18924  
## 21.97948 19.44056 12.3456655 26.53546 8.589853895 30.29127  
## 22.01231 19.43903 12.2777888 26.60027 8.486857875 30.39120  
## 22.04514 19.43855 12.2115779 26.66552 8.385849945 30.49125  
## 22.07798 19.43941 12.1473012 26.73153 8.287089938 30.59174  
## 22.11081 19.44016 12.0834860 26.79684 8.189096701 30.69123  
## 22.14364 19.44028 12.0195994 26.86096 8.091329477 30.78923  
## 22.17647 19.44053 11.9561967 26.92486 7.994231133 30.88682  
## 22.20930 19.44043 11.8928988 26.98795 7.897479038 30.98337  
## 22.24213 19.44051 11.8302733 27.05074 7.801659696 31.07935  
## 22.27497 19.44056 11.7681251 27.11300 7.706581873 31.17454  
## 22.30780 19.44079 11.7066452 27.17494 7.612434203 31.26915  
## 22.34063 19.44097 11.6455974 27.23634 7.518976182 31.36296  
## 22.37346 19.44068 11.5845616 27.29680 7.425782134 31.45558  
## 22.40629 19.44059 11.5241865 27.35699 7.333495342 31.54769  
## 22.43912 19.44116 11.4649274 27.41739 7.242565746 31.63975  
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## 30.81122 19.44337 1.9366249 36.95012 -7.330888258 46.21764  
## 30.84405 19.44337 1.9094379 36.97731 -7.372467192 46.25922  
## 30.87688 19.44337 1.8822930 37.00446 -7.413981763 46.30073  
## 30.90971 19.44337 1.8551900 37.03156 -7.455432256 46.34218  
## 30.94254 19.44337 1.8281286 37.05862 -7.496818963 46.38357  
## 30.97538 19.44337 1.8011088 37.08564 -7.538142188 46.42489  
## 31.00821 19.44337 1.7741304 37.11262 -7.579402227 46.46615  
## 31.04104 19.44337 1.7471930 37.13956 -7.620599362 46.50735  
## 31.07387 19.44337 1.7202966 37.16645 -7.661733885 46.54848  
## 31.10670 19.44337 1.6934409 37.19331 -7.702806076 46.58955  
## 31.13953 19.44337 1.6666258 37.22012 -7.743816219 46.63056  
## 31.17237 19.44337 1.6398511 37.24690 -7.784764593 46.67151  
## 31.20520 19.44337 1.6131166 37.27363 -7.825651477 46.71240  
## 31.23803 19.44337 1.5864222 37.30033 -7.866477150 46.75323  
## 31.27086 19.44337 1.5597675 37.32698 -7.907241883 46.79399  
## 31.30369 19.44337 1.5331526 37.35360 -7.947945944 46.83469  
## 31.33653 19.44337 1.5065771 37.38017 -7.988589610 46.87534  
## 31.36936 19.44337 1.4800410 37.40671 -8.029173146 46.91592  
## 31.40219 19.44337 1.4535440 37.43320 -8.069696820 46.95644  
## 31.43502 19.44337 1.4270859 37.45966 -8.110160892 46.99691  
## 31.46785 19.44337 1.4006667 37.48608 -8.150565630 47.03731  
## 31.50068 19.44337 1.3742861 37.51246 -8.190911287 47.07766  
## 31.53352 19.44337 1.3479439 37.53880 -8.231198131 47.11795  
## 31.56635 19.44337 1.3216401 37.56511 -8.271426414 47.15817  
## 31.59918 19.44337 1.2953743 37.59137 -8.311596388 47.19834  
## 31.63201 19.44337 1.2691466 37.61760 -8.351708307 47.23846  
## 31.66484 19.44337 1.2429566 37.64379 -8.391762427 47.27851  
## 31.69767 19.44337 1.2168042 37.66994 -8.431758991 47.31851  
## 31.73051 19.44337 1.1906894 37.69606 -8.471698249 47.35845  
## 31.76334 19.44337 1.1646118 37.72214 -8.511580443 47.39833  
## 31.79617 19.44337 1.1385714 37.74818 -8.551405819 47.43815  
## 31.82900 19.44337 1.1125680 37.77418 -8.591174622 47.47792  
## 31.86183 19.44337 1.0866014 37.80015 -8.630887092 47.51764  
## 31.89466 19.44337 1.0606715 37.82608 -8.670543465 47.55729  
## 31.92750 19.44337 1.0347781 37.85197 -8.710143976 47.59689  
## 31.96033 19.44337 1.0089211 37.87783 -8.749688864 47.63644  
## 31.99316 19.44337 0.9831003 37.90365 -8.789178363 47.67593  
## 32.02599 19.44337 0.9573155 37.92943 -8.828612705 47.71536  
## 32.05882 19.44337 0.9315667 37.95518 -8.867992119 47.75474  
## 32.09166 19.44337 0.9058537 37.98089 -8.907316836 47.79406  
## 32.12449 19.44337 0.8801762 38.00657 -8.946587081 47.83334  
## 32.15732 19.44337 0.8545343 38.03221 -8.985803080 47.87255

print(train\_forecast)

## Point Forecast Lo 80 Hi 80 Lo 95 Hi 95  
## 20.20657 19.36765 18.800777 19.93452 18.500694 20.23460  
## 20.23940 19.38737 18.406894 20.36786 17.887858 20.88689  
## 20.27223 19.39718 18.069043 20.72531 17.365971 21.42839  
## 20.30506 19.40156 17.777136 21.02598 16.917219 21.88590  
## 20.33789 19.40626 17.523667 21.28885 16.527083 22.28543  
## 20.37073 19.40934 17.296923 21.52175 16.178679 22.63999  
## 20.40356 19.40556 17.084854 21.72627 15.856346 22.95478  
## 20.43639 19.40437 16.892148 21.91659 15.562258 23.24648  
## 20.46922 19.41236 16.722056 22.10266 15.297896 23.52682  
## 20.50205 19.41428 16.556907 22.27164 15.044307 23.78424  
## 20.53488 19.41809 16.402872 22.43331 14.806712 24.02947  
## 20.56772 19.41950 16.254290 22.58472 14.578727 24.26028  
## 20.60055 19.42649 16.118066 22.73491 14.366694 24.48628  
## 20.63338 19.42816 15.982476 22.87384 14.158441 24.69788  
## 20.66621 19.43760 15.859917 23.01528 13.966006 24.90919  
## 20.69904 19.43724 15.732257 23.14222 13.770957 25.10352  
## 20.73187 19.43499 15.606940 23.26305 13.580492 25.28949  
## 20.76471 19.43705 15.489758 23.38433 13.400190 25.47390  
## 20.79754 19.44092 15.377893 23.50394 13.227058 25.65478  
## 20.83037 19.43502 15.259461 23.61057 13.049057 25.82097  
## 20.86320 19.43304 15.147909 23.71817 12.879498 25.98658  
## 20.89603 19.42819 15.036212 23.82016 12.711242 26.14513  
## 20.92886 19.43141 14.935135 23.92769 12.554949 26.30788  
## 20.96170 19.43431 14.836092 24.03253 12.401943 26.46667  
## 20.99453 19.43286 14.734914 24.13080 12.247972 26.61775  
## 21.02736 19.42712 14.631520 24.22272 12.092883 26.76136  
## 21.06019 19.42533 14.534028 24.31664 11.944728 26.90594  
## 21.09302 19.42856 14.443391 24.41374 11.804399 27.05273  
## 21.12585 19.43136 14.354057 24.50867 11.666294 27.19643  
## 21.15869 19.43180 14.263998 24.59959 11.528332 27.33526  
## 21.19152 19.43273 14.174955 24.69050 11.391657 27.47380  
## 21.22435 19.43235 14.085687 24.77901 11.255335 27.60937  
## 21.25718 19.43265 13.998377 24.86691 11.121649 27.74364  
## 21.29001 19.43286 13.912306 24.95342 10.989901 27.87582  
## 21.32285 19.43372 13.828184 25.03926 10.860790 28.00666  
## 21.35568 19.43439 13.745117 25.12365 10.733400 28.13537  
## 21.38851 19.43331 13.661524 25.20510 10.606125 28.26050  
## 21.42134 19.43296 13.579821 25.28611 10.481354 28.38457  
## 21.45417 19.43509 13.501703 25.36847 10.360759 28.50942  
## 21.48700 19.43560 13.423040 25.44815 10.240184 28.63101  
## 21.51984 19.43661 13.345915 25.52731 10.121693 28.75154  
## 21.55267 19.43699 13.269140 25.60484 10.004076 28.86991  
## 21.58550 19.43886 13.194807 25.68291 9.889406 28.98831  
## 21.61833 19.43931 13.119973 25.75864 9.774720 29.10389  
## 21.65116 19.44183 13.048103 25.83556 9.663468 29.22019  
## 21.68399 19.44173 12.974468 25.90900 9.550904 29.33256  
## 21.71683 19.44113 12.901155 25.98111 9.439100 29.44317  
## 21.74966 19.44168 12.829792 26.05357 9.329668 29.55370  
## 21.78249 19.44272 12.759688 26.12575 9.221907 29.66353  
## 21.81532 19.44114 12.687721 26.19456 9.112677 29.76960  
## 21.84815 19.44061 12.617529 26.26369 9.005608 29.87561  
## 21.88098 19.43931 12.547273 26.33135 8.898847 29.97978  
## 21.91382 19.44018 12.479860 26.40049 8.795291 30.08506  
## 21.94665 19.44095 12.413021 26.46888 8.692661 30.18924  
## 21.97948 19.44056 12.345665 26.53546 8.589854 30.29127  
## 22.01231 19.43903 12.277789 26.60027 8.486858 30.39120  
## 22.04514 19.43855 12.211578 26.66552 8.385850 30.49125  
## 22.07798 19.43941 12.147301 26.73153 8.287090 30.59174  
## 22.11081 19.44016 12.083486 26.79684 8.189097 30.69123  
## 22.14364 19.44028 12.019599 26.86096 8.091329 30.78923  
## 22.17647 19.44053 11.956197 26.92486 7.994231 30.88682  
## 22.20930 19.44043 11.892899 26.98795 7.897479 30.98337  
## 22.24213 19.44051 11.830273 27.05074 7.801660 31.07935  
## 22.27497 19.44056 11.768125 27.11300 7.706582 31.17454  
## 22.30780 19.44079 11.706645 27.17494 7.612434 31.26915  
## 22.34063 19.44097 11.645597 27.23634 7.518976 31.36296  
## 22.37346 19.44068 11.584562 27.29680 7.425782 31.45558  
## 22.40629 19.44059 11.524186 27.35699 7.333495 31.54769  
## 22.43912 19.44116 11.464927 27.41739 7.242566 31.63975  
## 22.47196 19.44129 11.405682 27.47691 7.151885 31.73070  
## 22.50479 19.44157 11.347008 27.53613 7.062007 31.82113  
## 22.53762 19.44167 11.288589 27.59475 6.972609 31.91073  
## 22.57045 19.44217 11.230985 27.65335 6.884248 32.00009  
## 22.60328 19.44229 11.173410 27.71116 6.796131 32.08844  
## 22.63611 19.44296 11.116790 27.76913 6.709181 32.17674  
## 22.66895 19.44294 11.059861 27.82601 6.622129 32.26374  
## 22.70178 19.44277 11.003180 27.88237 6.535529 32.35002  
## 22.73461 19.44292 10.947183 27.93866 6.449811 32.43603  
## 22.76744 19.44320 10.891685 27.99471 6.364787 32.52161  
## 22.80027 19.44278 10.835849 28.04970 6.279617 32.60594  
## 22.83311 19.44264 10.780649 28.10462 6.195270 32.69000  
## 22.86594 19.44229 10.725591 28.15899 6.111250 32.77333  
## 22.89877 19.44252 10.671451 28.21359 6.028328 32.85671  
## 22.93160 19.44273 10.617623 28.26783 5.945896 32.93956  
## 22.96443 19.44262 10.563813 28.32143 5.863655 33.02159  
## 22.99726 19.44221 10.510019 28.37440 5.781602 33.10282  
## 23.03010 19.44208 10.456825 28.42734 5.700317 33.18385  
## 23.06293 19.44232 10.404302 28.48033 5.619866 33.26476  
## 23.09576 19.44252 10.352053 28.53298 5.539853 33.34518  
## 23.12859 19.44255 10.299937 28.58516 5.460131 33.42496  
## 23.16142 19.44261 10.248108 28.63712 5.380832 33.50439  
## 23.19425 19.44259 10.196460 28.68871 5.301856 33.58332  
## 23.22709 19.44261 10.145139 28.74008 5.223357 33.66186  
## 23.25992 19.44262 10.094091 28.79115 5.145278 33.73997  
## 23.29275 19.44268 10.043366 28.84200 5.067668 33.81770  
## 23.32558 19.44273 9.992899 28.89256 4.990460 33.89500  
## 23.35841 19.44265 9.942576 28.94273 4.913539 33.97177  
## 23.39124 19.44263 9.892570 28.99269 4.837073 34.04819  
## 23.42408 19.44278 9.843000 29.04256 4.761183 34.12438  
## 23.45691 19.44282 9.793571 29.09206 4.685569 34.20007  
## 23.48974 19.44289 9.744431 29.14135 4.610377 34.27540  
## 23.52257 19.44292 9.695493 29.19034 4.535519 34.35032  
## 23.55540 19.44305 9.646907 29.23920 4.461142 34.42496  
## 23.58824 19.44308 9.598460 29.28771 4.387032 34.49913  
## 23.62107 19.44326 9.550400 29.33613 4.313434 34.57309  
## 23.65390 19.44326 9.502386 29.38413 4.240006 34.64651  
## 23.68673 19.44321 9.454566 29.43186 4.166896 34.71953  
## 23.71956 19.44325 9.407057 29.47945 4.094215 34.79229  
## 23.75239 19.44333 9.359806 29.52685 4.021913 34.86474  
## 23.78523 19.44321 9.312590 29.57384 3.949761 34.93667  
## 23.81806 19.44318 9.265666 29.62069 3.878018 35.00834  
## 23.85089 19.44308 9.218903 29.66726 3.806548 35.07962  
## 23.88372 19.44315 9.172506 29.71378 3.735558 35.15073  
## 23.91655 19.44320 9.126312 29.76009 3.664881 35.22152  
## 23.94938 19.44317 9.080241 29.80610 3.594437 35.29191  
## 23.98222 19.44306 9.034292 29.85183 3.524222 35.36190  
## 24.01505 19.44303 8.988620 29.89744 3.454390 35.43167  
## 24.04788 19.44309 8.943242 29.94294 3.384958 35.50122  
## 24.08071 19.44314 8.898051 29.98824 3.315816 35.57047  
## 24.11354 19.44315 8.853009 30.03330 3.246925 35.63938  
## 24.14637 19.44317 8.808157 30.07818 3.178321 35.70802  
## 24.17921 19.44316 8.763464 30.12286 3.109973 35.77635  
## 24.21204 19.44317 8.718969 30.16737 3.041920 35.84442  
## 24.24487 19.44317 8.674655 30.21169 2.974146 35.91220  
## 24.27770 19.44319 8.630535 30.25584 2.906662 35.97972  
## 24.31053 19.44320 8.586591 30.29981 2.839448 36.04696  
## 24.34337 19.44318 8.542790 30.34357 2.772472 36.11389  
## 24.37620 19.44317 8.499179 30.38717 2.705777 36.18057  
## 24.40903 19.44322 8.455788 30.43064 2.639395 36.24704  
## 24.44186 19.44323 8.412537 30.47391 2.573243 36.31321  
## 24.47469 19.44324 8.369464 30.51703 2.507359 36.37913  
## 24.50752 19.44325 8.326547 30.55996 2.441719 36.44479  
## 24.54036 19.44329 8.283823 30.60275 2.376359 36.51022  
## 24.57319 19.44330 8.241235 30.64536 2.311222 36.57537  
## 24.60602 19.44334 8.198849 30.68784 2.246372 36.64032  
## 24.63885 19.44334 8.156571 30.73011 2.181715 36.70497  
## 24.67168 19.44333 8.114442 30.77222 2.117290 36.76937  
## 24.70451 19.44334 8.072491 30.81419 2.053126 36.83356  
## 24.73735 19.44336 8.030703 30.85602 1.989207 36.89752  
## 24.77018 19.44333 7.989018 30.89764 1.925471 36.96119  
## 24.80301 19.44332 7.947504 30.93914 1.861986 37.02466  
## 24.83584 19.44330 7.906125 30.98047 1.798715 37.08788  
## 24.86867 19.44331 7.864934 31.02169 1.735711 37.15091  
## 24.90150 19.44333 7.823889 31.06277 1.672929 37.21373  
## 24.93434 19.44332 7.782965 31.10368 1.610346 37.27629  
## 24.96717 19.44329 7.742163 31.14442 1.547959 37.33862

###Creating complete visualization of final model compared to test set with annotations.

autoplot(train\_forecast, main = "Arima forecast including test data", xlab= "Number of Months", ylab= "Revenue in Millions") +  
 autolayer(test, series = "Test Data")+  
 autolayer(train, series = "Training Data") +  
 scale\_y\_continuous(sec.axis = sec\_axis(~., name = "Confidence Intervals at 80% / 95%", labels = NULL, breaks = NULL))

## Warning in min(x): no non-missing arguments to min; returning Inf

## Warning in max(x): no non-missing arguments to max; returning -Inf

