Project

Saim

12/6/2021

library(fpp3)

## ── Attaching packages ──────────────────────────────────────────── fpp3 0.4.0 ──

## ✓ tibble 3.1.4 ✓ tsibble 1.0.1   
## ✓ dplyr 1.0.7 ✓ tsibbledata 0.3.0   
## ✓ tidyr 1.1.3 ✓ feasts 0.2.2   
## ✓ lubridate 1.7.10 ✓ fable 0.3.1   
## ✓ ggplot2 3.3.5

## ── Conflicts ───────────────────────────────────────────────── fpp3\_conflicts ──  
## x lubridate::date() masks base::date()  
## x dplyr::filter() masks stats::filter()  
## x tsibble::intersect() masks base::intersect()  
## x tsibble::interval() masks lubridate::interval()  
## x dplyr::lag() masks stats::lag()  
## x tsibble::setdiff() masks base::setdiff()  
## x tsibble::union() masks base::union()

library(tidyverse)

## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.1 ──

## ✓ readr 2.0.1 ✓ stringr 1.4.0  
## ✓ purrr 0.3.4 ✓ forcats 0.5.1

## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## x lubridate::as.difftime() masks base::as.difftime()  
## x lubridate::date() masks base::date()  
## x dplyr::filter() masks stats::filter()  
## x tsibble::intersect() masks lubridate::intersect(), base::intersect()  
## x tsibble::interval() masks lubridate::interval()  
## x dplyr::lag() masks stats::lag()  
## x tsibble::setdiff() masks lubridate::setdiff(), base::setdiff()  
## x tsibble::union() masks lubridate::union(), base::union()

library(urca)

data = readr::read\_csv('INDCPIALLMINMEI.csv')

## Rows: 741 Columns: 2

## ── Column specification ────────────────────────────────────────────────────────  
## Delimiter: ","  
## dbl (1): INDCPIALLMINMEI  
## date (1): DATE

##   
## 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.

data\_tsibble = data%>%mutate(DATE=yearmonth(DATE))%>%as\_tsibble(index=DATE)  
data\_hold = data\_tsibble%>%filter\_index('1960 Jan'~'2021 May')

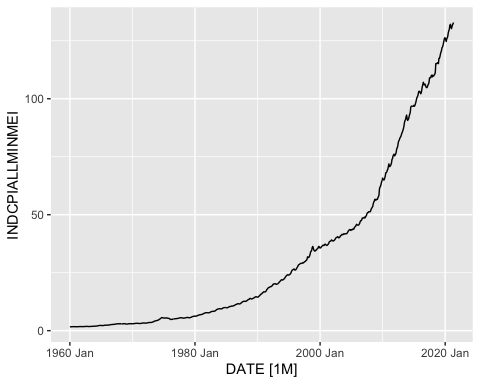
*Data needs trasnformation BOX-COX*

lambda\_val = data\_hold%>%features(INDCPIALLMINMEI,guerrero)%>%  
 pull(lambda\_guerrero)  
lambda\_val

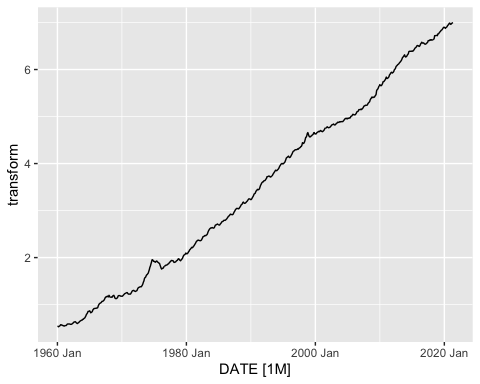
## [1] 0.1389429

data\_hold=data\_hold%>%  
 mutate(transform=box\_cox(INDCPIALLMINMEI,lambda\_val))  
data\_hold%>%autoplot()

## Plot variable not specified, automatically selected `.vars = INDCPIALLMINMEI`



data\_hold%>%autoplot(transform)



*WE NEED TO CHECK IF SEASONAL DIFFERENCING IS NEEDED*

data\_hold%>%features(transform,unitroot\_nsdiffs)

## # A tibble: 1 × 1  
## nsdiffs  
## <int>  
## 1 1

*The response is 1 and hence it is an indication to set D = 1.*

*Now we need to conduct an ADF test to set the value of d. Inorder to conduct an ADF test we must convert the desired forcast variable to a time series format.*

ur\_test = as.ts(select(data\_hold,transform))

*ADF TEST for non sesonal component. The first thing that we are going to do here is figure our the appropriate number of lags that explains all the variations in our data.*

ur.df((ur\_test),type = 'trend',lags = 30 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression trend   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.043959 -0.006510 0.000045 0.006418 0.048928   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.970e-03 1.171e-03 3.389 0.000743 \*\*\*  
## z.lag.1 -7.729e-03 3.131e-03 -2.469 0.013813 \*   
## tt 7.440e-05 2.921e-05 2.547 0.011073 \*   
## z.diff.lag1 3.443e-01 3.828e-02 8.994 < 2e-16 \*\*\*  
## z.diff.lag2 -4.230e-02 4.046e-02 -1.046 0.296128   
## z.diff.lag3 1.048e-01 4.046e-02 2.591 0.009782 \*\*   
## z.diff.lag4 -2.231e-02 4.049e-02 -0.551 0.581820   
## z.diff.lag5 -1.100e-02 4.056e-02 -0.271 0.786379   
## z.diff.lag6 1.171e-01 4.062e-02 2.883 0.004064 \*\*   
## z.diff.lag7 -1.390e-01 4.042e-02 -3.440 0.000618 \*\*\*  
## z.diff.lag8 9.147e-02 4.078e-02 2.243 0.025231 \*   
## z.diff.lag9 5.605e-02 4.090e-02 1.370 0.171041   
## z.diff.lag10 1.018e-01 4.095e-02 2.486 0.013145 \*   
## z.diff.lag11 -1.745e-02 4.113e-02 -0.424 0.671435   
## z.diff.lag12 1.591e-01 4.091e-02 3.889 0.000111 \*\*\*  
## z.diff.lag13 -5.355e-02 4.131e-02 -1.296 0.195268   
## z.diff.lag14 -2.833e-02 4.134e-02 -0.685 0.493414   
## z.diff.lag15 -2.414e-02 4.143e-02 -0.583 0.560352   
## z.diff.lag16 -1.092e-02 4.138e-02 -0.264 0.792018   
## z.diff.lag17 -5.169e-02 4.140e-02 -1.249 0.212249   
## z.diff.lag18 -5.292e-02 4.143e-02 -1.277 0.201901   
## z.diff.lag19 -1.163e-01 4.096e-02 -2.840 0.004651 \*\*   
## z.diff.lag20 3.405e-02 4.117e-02 0.827 0.408517   
## z.diff.lag21 7.236e-03 4.102e-02 0.176 0.860014   
## z.diff.lag22 -4.105e-02 4.097e-02 -1.002 0.316757   
## z.diff.lag23 1.722e-02 4.081e-02 0.422 0.673234   
## z.diff.lag24 1.529e-01 4.045e-02 3.780 0.000171 \*\*\*  
## z.diff.lag25 3.788e-03 4.065e-02 0.093 0.925783   
## z.diff.lag26 -7.366e-03 4.065e-02 -0.181 0.856249   
## z.diff.lag27 1.084e-01 4.067e-02 2.665 0.007894 \*\*   
## z.diff.lag28 -4.232e-02 4.077e-02 -1.038 0.299630   
## z.diff.lag29 -6.326e-02 4.108e-02 -1.540 0.124083   
## z.diff.lag30 -6.758e-02 3.889e-02 -1.737 0.082773 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01109 on 673 degrees of freedom  
## Multiple R-squared: 0.3963, Adjusted R-squared: 0.3676   
## F-statistic: 13.81 on 32 and 673 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.4686 9.5327 3.7274   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau3 -3.96 -3.41 -3.12  
## phi2 6.09 4.68 4.03  
## phi3 8.27 6.25 5.34

ur.df((ur\_test),type = 'trend',lags = 40 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression trend   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.041049 -0.005967 0.000179 0.005931 0.050311   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.210e-03 1.273e-03 2.522 0.011912 \*   
## z.lag.1 -8.201e-03 3.248e-03 -2.525 0.011812 \*   
## tt 7.776e-05 3.036e-05 2.561 0.010645 \*   
## z.diff.lag1 3.286e-01 3.843e-02 8.550 < 2e-16 \*\*\*  
## z.diff.lag2 -4.524e-02 4.054e-02 -1.116 0.264809   
## z.diff.lag3 1.018e-01 4.058e-02 2.510 0.012315 \*   
## z.diff.lag4 -6.263e-03 4.079e-02 -0.154 0.878017   
## z.diff.lag5 1.133e-03 4.083e-02 0.028 0.977875   
## z.diff.lag6 1.264e-01 4.081e-02 3.096 0.002045 \*\*   
## z.diff.lag7 -1.226e-01 4.102e-02 -2.990 0.002896 \*\*   
## z.diff.lag8 8.889e-02 4.124e-02 2.155 0.031491 \*   
## z.diff.lag9 3.552e-02 4.132e-02 0.860 0.390267   
## z.diff.lag10 9.783e-02 4.120e-02 2.374 0.017867 \*   
## z.diff.lag11 -2.364e-02 4.137e-02 -0.571 0.567916   
## z.diff.lag12 1.346e-01 4.137e-02 3.252 0.001204 \*\*   
## z.diff.lag13 -5.538e-02 4.147e-02 -1.336 0.182167   
## z.diff.lag14 -1.970e-02 4.156e-02 -0.474 0.635641   
## z.diff.lag15 -2.267e-02 4.165e-02 -0.544 0.586531   
## z.diff.lag16 -6.692e-03 4.166e-02 -0.161 0.872430   
## z.diff.lag17 -2.928e-02 4.164e-02 -0.703 0.482279   
## z.diff.lag18 -3.954e-02 4.153e-02 -0.952 0.341494   
## z.diff.lag19 -9.943e-02 4.153e-02 -2.394 0.016950 \*   
## z.diff.lag20 3.652e-02 4.166e-02 0.876 0.381094   
## z.diff.lag21 1.470e-02 4.169e-02 0.353 0.724435   
## z.diff.lag22 -3.845e-02 4.165e-02 -0.923 0.356292   
## z.diff.lag23 1.484e-02 4.168e-02 0.356 0.721872   
## z.diff.lag24 1.180e-01 4.161e-02 2.835 0.004720 \*\*   
## z.diff.lag25 9.839e-04 4.147e-02 0.024 0.981081   
## z.diff.lag26 -1.971e-02 4.143e-02 -0.476 0.634413   
## z.diff.lag27 8.901e-02 4.131e-02 2.155 0.031532 \*   
## z.diff.lag28 -4.173e-02 4.147e-02 -1.006 0.314759   
## z.diff.lag29 -5.405e-02 4.163e-02 -1.298 0.194601   
## z.diff.lag30 -7.321e-02 4.154e-02 -1.762 0.078495 .   
## z.diff.lag31 -3.428e-02 4.147e-02 -0.827 0.408715   
## z.diff.lag32 -1.508e-02 4.151e-02 -0.363 0.716588   
## z.diff.lag33 2.105e-02 4.147e-02 0.508 0.611972   
## z.diff.lag34 1.013e-02 4.144e-02 0.244 0.806998   
## z.diff.lag35 2.021e-02 4.193e-02 0.482 0.630051   
## z.diff.lag36 1.513e-01 3.959e-02 3.822 0.000145 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01103 on 657 degrees of freedom  
## Multiple R-squared: 0.4101, Adjusted R-squared: 0.3759   
## F-statistic: 12.02 on 38 and 657 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.5247 6.4115 3.3687   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau3 -3.96 -3.41 -3.12  
## phi2 6.09 4.68 4.03  
## phi3 8.27 6.25 5.34

ur.df((ur\_test),type = 'trend',lags = 50 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression trend   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.041045 -0.006011 0.000247 0.005791 0.050026   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.627e-03 1.344e-03 1.955 0.051048 .   
## z.lag.1 -9.370e-03 3.372e-03 -2.778 0.005622 \*\*   
## tt 8.915e-05 3.161e-05 2.821 0.004942 \*\*   
## z.diff.lag1 3.318e-01 3.867e-02 8.580 < 2e-16 \*\*\*  
## z.diff.lag2 -5.009e-02 4.080e-02 -1.228 0.220024   
## z.diff.lag3 1.048e-01 4.083e-02 2.566 0.010515 \*   
## z.diff.lag4 -6.560e-03 4.100e-02 -0.160 0.872934   
## z.diff.lag5 3.929e-03 4.102e-02 0.096 0.923711   
## z.diff.lag6 1.257e-01 4.102e-02 3.065 0.002267 \*\*   
## z.diff.lag7 -1.200e-01 4.123e-02 -2.911 0.003721 \*\*   
## z.diff.lag8 8.847e-02 4.146e-02 2.134 0.033239 \*   
## z.diff.lag9 3.655e-02 4.154e-02 0.880 0.379252   
## z.diff.lag10 1.018e-01 4.144e-02 2.457 0.014286 \*   
## z.diff.lag11 -2.448e-02 4.162e-02 -0.588 0.556610   
## z.diff.lag12 1.408e-01 4.162e-02 3.384 0.000759 \*\*\*  
## z.diff.lag13 -5.432e-02 4.176e-02 -1.301 0.193797   
## z.diff.lag14 -1.767e-02 4.179e-02 -0.423 0.672625   
## z.diff.lag15 -1.959e-02 4.189e-02 -0.468 0.640236   
## z.diff.lag16 -9.019e-03 4.183e-02 -0.216 0.829360   
## z.diff.lag17 -2.641e-02 4.182e-02 -0.632 0.527841   
## z.diff.lag18 -3.962e-02 4.168e-02 -0.950 0.342263   
## z.diff.lag19 -9.940e-02 4.168e-02 -2.385 0.017368 \*   
## z.diff.lag20 3.766e-02 4.181e-02 0.901 0.368089   
## z.diff.lag21 1.519e-02 4.183e-02 0.363 0.716680   
## z.diff.lag22 -3.950e-02 4.180e-02 -0.945 0.344982   
## z.diff.lag23 1.650e-02 4.184e-02 0.394 0.693385   
## z.diff.lag24 1.172e-01 4.179e-02 2.805 0.005186 \*\*   
## z.diff.lag25 2.728e-03 4.166e-02 0.065 0.947804   
## z.diff.lag26 -1.848e-02 4.164e-02 -0.444 0.657399   
## z.diff.lag27 8.870e-02 4.151e-02 2.137 0.032987 \*   
## z.diff.lag28 -3.843e-02 4.168e-02 -0.922 0.356801   
## z.diff.lag29 -5.269e-02 4.187e-02 -1.259 0.208638   
## z.diff.lag30 -7.254e-02 4.177e-02 -1.737 0.082927 .   
## z.diff.lag31 -3.253e-02 4.170e-02 -0.780 0.435650   
## z.diff.lag32 -1.315e-02 4.175e-02 -0.315 0.752856   
## z.diff.lag33 2.267e-02 4.173e-02 0.543 0.587075   
## z.diff.lag34 1.130e-02 4.171e-02 0.271 0.786455   
## z.diff.lag35 2.110e-02 4.221e-02 0.500 0.617278   
## z.diff.lag36 1.536e-01 3.985e-02 3.855 0.000127 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01106 on 647 degrees of freedom  
## Multiple R-squared: 0.4145, Adjusted R-squared: 0.3801   
## F-statistic: 12.05 on 38 and 647 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.7783 6.3577 4.1047   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau3 -3.96 -3.41 -3.12  
## phi2 6.09 4.68 4.03  
## phi3 8.27 6.25 5.34

ur.df((ur\_test),type = 'trend',lags = 100 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression trend   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.039469 -0.006412 0.000256 0.005892 0.049206   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 6.975e-04 1.571e-03 0.444 0.657300   
## z.lag.1 -1.443e-02 4.184e-03 -3.449 0.000603 \*\*\*  
## tt 1.393e-04 4.004e-05 3.480 0.000538 \*\*\*  
## z.diff.lag1 3.449e-01 4.008e-02 8.604 < 2e-16 \*\*\*  
## z.diff.lag2 -4.946e-02 4.251e-02 -1.163 0.245169   
## z.diff.lag3 7.349e-02 4.249e-02 1.730 0.084235 .   
## z.diff.lag4 3.358e-02 4.244e-02 0.791 0.429144   
## z.diff.lag5 -6.921e-03 4.187e-02 -0.165 0.868759   
## z.diff.lag6 1.298e-01 4.177e-02 3.107 0.001982 \*\*   
## z.diff.lag7 -1.372e-01 4.201e-02 -3.265 0.001156 \*\*   
## z.diff.lag8 1.001e-01 4.229e-02 2.368 0.018200 \*   
## z.diff.lag9 4.685e-02 4.236e-02 1.106 0.269218   
## z.diff.lag10 7.876e-02 4.226e-02 1.864 0.062820 .   
## z.diff.lag11 -1.732e-02 4.229e-02 -0.410 0.682218   
## z.diff.lag12 1.454e-01 4.215e-02 3.449 0.000602 \*\*\*  
## z.diff.lag13 -6.585e-02 4.236e-02 -1.555 0.120582   
## z.diff.lag14 -5.567e-03 4.248e-02 -0.131 0.895793   
## z.diff.lag15 1.138e-02 4.259e-02 0.267 0.789489   
## z.diff.lag16 -1.973e-02 4.259e-02 -0.463 0.643304   
## z.diff.lag17 -1.422e-02 4.252e-02 -0.334 0.738257   
## z.diff.lag18 -3.476e-02 4.223e-02 -0.823 0.410860   
## z.diff.lag19 -1.117e-01 4.222e-02 -2.647 0.008340 \*\*   
## z.diff.lag20 3.885e-02 4.243e-02 0.916 0.360205   
## z.diff.lag21 2.258e-02 4.245e-02 0.532 0.595008   
## z.diff.lag22 -2.840e-02 4.244e-02 -0.669 0.503650   
## z.diff.lag23 3.321e-04 4.247e-02 0.008 0.993764   
## z.diff.lag24 1.312e-01 4.239e-02 3.095 0.002057 \*\*   
## z.diff.lag25 -1.152e-03 4.224e-02 -0.027 0.978244   
## z.diff.lag26 -2.876e-02 4.218e-02 -0.682 0.495577   
## z.diff.lag27 1.001e-01 4.208e-02 2.380 0.017641 \*   
## z.diff.lag28 -4.015e-02 4.230e-02 -0.949 0.342908   
## z.diff.lag29 -5.552e-02 4.246e-02 -1.308 0.191469   
## z.diff.lag30 -8.416e-02 4.233e-02 -1.989 0.047212 \*   
## z.diff.lag31 -1.479e-02 4.228e-02 -0.350 0.726665   
## z.diff.lag32 -8.928e-03 4.225e-02 -0.211 0.832723   
## z.diff.lag33 1.682e-02 4.224e-02 0.398 0.690643   
## z.diff.lag34 3.546e-02 4.226e-02 0.839 0.401647   
## z.diff.lag35 2.917e-02 4.268e-02 0.683 0.494640   
## z.diff.lag36 1.417e-01 4.039e-02 3.507 0.000487 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01087 on 597 degrees of freedom  
## Multiple R-squared: 0.4387, Adjusted R-squared: 0.403   
## F-statistic: 12.28 on 38 and 597 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -3.4485 7.4239 6.1388   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau3 -3.96 -3.41 -3.12  
## phi2 6.09 4.68 4.03  
## phi3 8.27 6.25 5.34

* Total of 36 lags are sufficient enough to describe all variations in our data\*

*ADF with 36 Lag periods*

ur.df((ur\_test),type = 'trend',lags = 36 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression trend   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.041127 -0.005988 0.000210 0.005954 0.050331   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 3.254e-03 1.241e-03 2.623 0.008925 \*\*   
## z.lag.1 -8.125e-03 3.196e-03 -2.543 0.011233 \*   
## tt 7.703e-05 2.984e-05 2.582 0.010045 \*   
## z.diff.lag1 3.280e-01 3.831e-02 8.560 < 2e-16 \*\*\*  
## z.diff.lag2 -4.459e-02 4.039e-02 -1.104 0.270008   
## z.diff.lag3 1.012e-01 4.042e-02 2.505 0.012495 \*   
## z.diff.lag4 -7.522e-03 4.063e-02 -0.185 0.853200   
## z.diff.lag5 2.234e-03 4.068e-02 0.055 0.956219   
## z.diff.lag6 1.256e-01 4.068e-02 3.087 0.002109 \*\*   
## z.diff.lag7 -1.225e-01 4.090e-02 -2.996 0.002838 \*\*   
## z.diff.lag8 8.897e-02 4.114e-02 2.163 0.030921 \*   
## z.diff.lag9 3.533e-02 4.122e-02 0.857 0.391767   
## z.diff.lag10 9.822e-02 4.110e-02 2.390 0.017145 \*   
## z.diff.lag11 -2.380e-02 4.126e-02 -0.577 0.564227   
## z.diff.lag12 1.340e-01 4.127e-02 3.247 0.001225 \*\*   
## z.diff.lag13 -5.420e-02 4.134e-02 -1.311 0.190248   
## z.diff.lag14 -2.103e-02 4.143e-02 -0.507 0.611977   
## z.diff.lag15 -2.231e-02 4.153e-02 -0.537 0.591393   
## z.diff.lag16 -6.368e-03 4.154e-02 -0.153 0.878194   
## z.diff.lag17 -2.970e-02 4.154e-02 -0.715 0.474766   
## z.diff.lag18 -3.947e-02 4.143e-02 -0.953 0.341103   
## z.diff.lag19 -1.007e-01 4.140e-02 -2.432 0.015274 \*   
## z.diff.lag20 3.791e-02 4.154e-02 0.913 0.361752   
## z.diff.lag21 1.433e-02 4.156e-02 0.345 0.730285   
## z.diff.lag22 -3.805e-02 4.150e-02 -0.917 0.359529   
## z.diff.lag23 1.283e-02 4.151e-02 0.309 0.757446   
## z.diff.lag24 1.193e-01 4.146e-02 2.878 0.004130 \*\*   
## z.diff.lag25 1.490e-03 4.131e-02 0.036 0.971241   
## z.diff.lag26 -2.151e-02 4.127e-02 -0.521 0.602402   
## z.diff.lag27 9.104e-02 4.113e-02 2.213 0.027214 \*   
## z.diff.lag28 -4.311e-02 4.131e-02 -1.044 0.297078   
## z.diff.lag29 -5.282e-02 4.146e-02 -1.274 0.203094   
## z.diff.lag30 -7.442e-02 4.138e-02 -1.799 0.072551 .   
## z.diff.lag31 -3.511e-02 4.131e-02 -0.850 0.395764   
## z.diff.lag32 -1.414e-02 4.135e-02 -0.342 0.732540   
## z.diff.lag33 2.044e-02 4.135e-02 0.494 0.621308   
## z.diff.lag34 9.921e-03 4.131e-02 0.240 0.810303   
## z.diff.lag35 2.175e-02 4.177e-02 0.521 0.602733   
## z.diff.lag36 1.496e-01 3.945e-02 3.793 0.000163 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01101 on 661 degrees of freedom  
## Multiple R-squared: 0.4107, Adjusted R-squared: 0.3768   
## F-statistic: 12.12 on 38 and 661 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.5425 6.4726 3.4325   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau3 -3.96 -3.41 -3.12  
## phi2 6.09 4.68 4.03  
## phi3 8.27 6.25 5.34

* Here we can see that our test statistics is greater than the critical values for a test size of 1,5 and 10 percent. - 2.5435 > -3.41 therefore, we would fail to reject a unit root here and we can conclude that d=1.\*

*Now we would verify the existance of a seasonal unit root by differencing our data* \* Maximizing the lags to explain all the variation in the data \*

ur.df(diff(ur\_test,12),type = 'drift',lags = 30 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression drift   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.042175 -0.006896 0.000023 0.006572 0.048799   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.005073 0.001262 4.019 6.52e-05 \*\*\*  
## z.lag.1 -0.045910 0.010937 -4.198 3.06e-05 \*\*\*  
## z.diff.lag1 0.352211 0.038542 9.138 < 2e-16 \*\*\*  
## z.diff.lag2 -0.017274 0.040816 -0.423 0.67227   
## z.diff.lag3 0.105840 0.040823 2.593 0.00973 \*\*   
## z.diff.lag4 0.039706 0.040987 0.969 0.33303   
## z.diff.lag5 0.108092 0.040961 2.639 0.00851 \*\*   
## z.diff.lag6 0.167977 0.038495 4.364 1.48e-05 \*\*\*  
## z.diff.lag7 -0.032281 0.038939 -0.829 0.40739   
## z.diff.lag8 0.096294 0.038949 2.472 0.01367 \*   
## z.diff.lag9 0.028052 0.039090 0.718 0.47324   
## z.diff.lag10 0.126294 0.039063 3.233 0.00129 \*\*   
## z.diff.lag11 -0.013457 0.039222 -0.343 0.73164   
## z.diff.lag12 -0.636594 0.039178 -16.249 < 2e-16 \*\*\*  
## z.diff.lag13 0.204049 0.046201 4.416 1.17e-05 \*\*\*  
## z.diff.lag14 -0.026217 0.046851 -0.560 0.57594   
## z.diff.lag15 0.025166 0.046872 0.537 0.59150   
## z.diff.lag16 0.027061 0.046864 0.577 0.56384   
## z.diff.lag17 0.125348 0.046633 2.688 0.00737 \*\*   
## z.diff.lag18 0.093259 0.038823 2.402 0.01657 \*   
## z.diff.lag19 -0.061479 0.038913 -1.580 0.11460   
## z.diff.lag20 0.075155 0.038883 1.933 0.05368 .   
## z.diff.lag21 0.009793 0.038979 0.251 0.80171   
## z.diff.lag22 0.032835 0.039027 0.841 0.40047   
## z.diff.lag23 -0.014201 0.039283 -0.361 0.71784   
## z.diff.lag24 -0.351813 0.039081 -9.002 < 2e-16 \*\*\*  
## z.diff.lag25 0.121638 0.041257 2.948 0.00331 \*\*   
## z.diff.lag26 -0.043345 0.041530 -1.044 0.29700   
## z.diff.lag27 0.066293 0.041445 1.600 0.11017   
## z.diff.lag28 -0.017893 0.041455 -0.432 0.66615   
## z.diff.lag29 0.105702 0.039404 2.683 0.00749 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01177 on 663 degrees of freedom  
## Multiple R-squared: 0.4653, Adjusted R-squared: 0.4411   
## F-statistic: 19.23 on 30 and 663 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -4.1977 8.8452   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau2 -3.43 -2.86 -2.57  
## phi1 6.43 4.59 3.78

ur.df(diff(ur\_test,12),type = 'drift',lags = 40 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression drift   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.042940 -0.006845 -0.000273 0.006677 0.049058   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.004768 0.001368 3.485 0.000525 \*\*\*  
## z.lag.1 -0.043557 0.011941 -3.648 0.000286 \*\*\*  
## z.diff.lag1 0.348907 0.039426 8.850 < 2e-16 \*\*\*  
## z.diff.lag2 -0.003599 0.040535 -0.089 0.929288   
## z.diff.lag3 0.103700 0.040531 2.559 0.010739 \*   
## z.diff.lag4 0.041296 0.040764 1.013 0.311418   
## z.diff.lag5 0.079326 0.040899 1.940 0.052870 .   
## z.diff.lag6 0.182966 0.040910 4.472 9.14e-06 \*\*\*  
## z.diff.lag7 -0.034958 0.041395 -0.844 0.398708   
## z.diff.lag8 0.108583 0.041407 2.622 0.008939 \*\*   
## z.diff.lag9 0.055636 0.041600 1.337 0.181560   
## z.diff.lag10 0.137725 0.041618 3.309 0.000987 \*\*\*  
## z.diff.lag11 -0.010170 0.041963 -0.242 0.808576   
## z.diff.lag12 -0.722975 0.041861 -17.271 < 2e-16 \*\*\*  
## z.diff.lag13 0.224564 0.050360 4.459 9.70e-06 \*\*\*  
## z.diff.lag14 -0.015655 0.046576 -0.336 0.736891   
## z.diff.lag15 0.020953 0.046522 0.450 0.652582   
## z.diff.lag16 0.025166 0.046563 0.540 0.589063   
## z.diff.lag17 0.093195 0.046876 1.988 0.047221 \*   
## z.diff.lag18 0.134870 0.046986 2.870 0.004234 \*\*   
## z.diff.lag19 -0.077724 0.047069 -1.651 0.099169 .   
## z.diff.lag20 0.111833 0.047009 2.379 0.017651 \*   
## z.diff.lag21 0.044639 0.047182 0.946 0.344449   
## z.diff.lag22 0.067684 0.047280 1.432 0.152753   
## z.diff.lag23 -0.017555 0.047542 -0.369 0.712063   
## z.diff.lag24 -0.510527 0.047491 -10.750 < 2e-16 \*\*\*  
## z.diff.lag25 0.167350 0.050948 3.285 0.001076 \*\*   
## z.diff.lag26 -0.023258 0.041499 -0.560 0.575360   
## z.diff.lag27 0.048902 0.041442 1.180 0.238432   
## z.diff.lag28 -0.020016 0.041349 -0.484 0.628490   
## z.diff.lag29 0.075761 0.041347 1.832 0.067363 .   
## z.diff.lag30 0.049093 0.041399 1.186 0.236113   
## z.diff.lag31 -0.044447 0.041353 -1.075 0.282860   
## z.diff.lag32 0.067591 0.041111 1.644 0.100645   
## z.diff.lag33 0.064061 0.041148 1.557 0.119998   
## z.diff.lag34 0.057302 0.041215 1.390 0.164911   
## z.diff.lag35 0.005890 0.041150 0.143 0.886231   
## z.diff.lag36 -0.221369 0.041129 -5.382 1.03e-07 \*\*\*  
## z.diff.lag37 0.077459 0.040058 1.934 0.053593 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01152 on 645 degrees of freedom  
## Multiple R-squared: 0.4958, Adjusted R-squared: 0.4661   
## F-statistic: 16.69 on 38 and 645 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -3.6477 6.658   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau2 -3.43 -2.86 -2.57  
## phi1 6.43 4.59 3.78

ur.df(diff(ur\_test,12),type = 'drift',lags = 60 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression drift   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.034494 -0.006490 -0.000229 0.006120 0.051370   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.005236 0.001701 3.078 0.002178 \*\*   
## z.lag.1 -0.047754 0.015104 -3.162 0.001648 \*\*   
## z.diff.lag1 0.333685 0.040412 8.257 9.48e-16 \*\*\*  
## z.diff.lag2 0.022884 0.042590 0.537 0.591245   
## z.diff.lag3 0.091402 0.042543 2.148 0.032074 \*   
## z.diff.lag4 0.071388 0.042705 1.672 0.095112 .   
## z.diff.lag5 0.124613 0.042695 2.919 0.003647 \*\*   
## z.diff.lag6 0.164389 0.042993 3.824 0.000145 \*\*\*  
## z.diff.lag7 -0.027277 0.043420 -0.628 0.530108   
## z.diff.lag8 0.114156 0.043439 2.628 0.008809 \*\*   
## z.diff.lag9 0.050965 0.043676 1.167 0.243719   
## z.diff.lag10 0.161931 0.043540 3.719 0.000219 \*\*\*  
## z.diff.lag11 -0.028452 0.043897 -0.648 0.517136   
## z.diff.lag12 -0.768571 0.043845 -17.529 < 2e-16 \*\*\*  
## z.diff.lag13 0.232532 0.052451 4.433 1.10e-05 \*\*\*  
## z.diff.lag14 0.013249 0.053050 0.250 0.802868   
## z.diff.lag15 0.013671 0.053071 0.258 0.796806   
## z.diff.lag16 0.045178 0.053105 0.851 0.395265   
## z.diff.lag17 0.164753 0.053021 3.107 0.001977 \*\*   
## z.diff.lag18 0.116540 0.053475 2.179 0.029694 \*   
## z.diff.lag19 -0.048878 0.053589 -0.912 0.362084   
## z.diff.lag20 0.126576 0.053566 2.363 0.018445 \*   
## z.diff.lag21 0.047612 0.053753 0.886 0.376107   
## z.diff.lag22 0.107361 0.053867 1.993 0.046705 \*   
## z.diff.lag23 -0.083860 0.054024 -1.552 0.121121   
## z.diff.lag24 -0.620401 0.054048 -11.479 < 2e-16 \*\*\*  
## z.diff.lag25 0.196435 0.056812 3.458 0.000583 \*\*\*  
## z.diff.lag26 0.015790 0.057120 0.276 0.782314   
## z.diff.lag27 0.032725 0.057084 0.573 0.566667   
## z.diff.lag28 0.027933 0.057086 0.489 0.624795   
## z.diff.lag29 0.160036 0.056928 2.811 0.005096 \*\*   
## z.diff.lag30 0.031705 0.057275 0.554 0.580089   
## z.diff.lag31 0.002851 0.057321 0.050 0.960347   
## z.diff.lag32 0.092509 0.057130 1.619 0.105914   
## z.diff.lag33 0.087413 0.057246 1.527 0.127293   
## z.diff.lag34 0.106294 0.057356 1.853 0.064340 .   
## z.diff.lag35 -0.079295 0.057552 -1.378 0.168781   
## z.diff.lag36 -0.420371 0.057361 -7.329 7.52e-13 \*\*\*  
## z.diff.lag37 0.132927 0.053596 2.480 0.013405 \*   
## z.diff.lag38 0.022682 0.053616 0.423 0.672420   
## z.diff.lag39 -0.030773 0.053578 -0.574 0.565938   
## z.diff.lag40 0.059548 0.053540 1.112 0.266487   
## z.diff.lag41 0.122822 0.053435 2.299 0.021874 \*   
## z.diff.lag42 -0.033889 0.053568 -0.633 0.527218   
## z.diff.lag43 0.060354 0.053569 1.127 0.260331   
## z.diff.lag44 0.055841 0.053453 1.045 0.296594   
## z.diff.lag45 0.019991 0.053451 0.374 0.708531   
## z.diff.lag46 0.052758 0.053441 0.987 0.323936   
## z.diff.lag47 -0.079811 0.053581 -1.490 0.136873   
## z.diff.lag48 -0.258040 0.053095 -4.860 1.50e-06 \*\*\*  
## z.diff.lag49 0.083881 0.042624 1.968 0.049534 \*   
## z.diff.lag50 0.044631 0.042636 1.047 0.295620   
## z.diff.lag51 -0.060043 0.042424 -1.415 0.157498   
## z.diff.lag52 0.068249 0.042548 1.604 0.109227   
## z.diff.lag53 0.007235 0.042525 0.170 0.864964   
## z.diff.lag54 -0.026197 0.042447 -0.617 0.537356   
## z.diff.lag55 0.065029 0.042289 1.538 0.124646   
## z.diff.lag56 0.089082 0.042200 2.111 0.035186 \*   
## z.diff.lag57 0.016769 0.042356 0.396 0.692318   
## z.diff.lag58 0.045010 0.042229 1.066 0.286913   
## z.diff.lag59 -0.016085 0.042357 -0.380 0.704268   
## z.diff.lag60 -0.205664 0.040573 -5.069 5.33e-07 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.0111 on 602 degrees of freedom  
## Multiple R-squared: 0.5503, Adjusted R-squared: 0.5047   
## F-statistic: 12.08 on 61 and 602 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -3.1617 5.0011   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau2 -3.43 -2.86 -2.57  
## phi1 6.43 4.59 3.78

ur.df(diff(ur\_test,12),type = 'drift',lags = 80 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression drift   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.03599 -0.00617 -0.00003 0.00597 0.05182   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.0041576 0.0018518 2.245 0.025142 \*   
## z.lag.1 -0.0376608 0.0164294 -2.292 0.022253 \*   
## z.diff.lag1 0.3546033 0.0425259 8.339 5.67e-16 \*\*\*  
## z.diff.lag2 -0.0067956 0.0450066 -0.151 0.880036   
## z.diff.lag3 0.0840115 0.0449426 1.869 0.062093 .   
## z.diff.lag4 0.0521600 0.0450187 1.159 0.247092   
## z.diff.lag5 0.1106106 0.0450927 2.453 0.014467 \*   
## z.diff.lag6 0.1518354 0.0452418 3.356 0.000843 \*\*\*  
## z.diff.lag7 -0.0352613 0.0456612 -0.772 0.440293   
## z.diff.lag8 0.0986420 0.0457220 2.157 0.031389 \*   
## z.diff.lag9 0.0418119 0.0456575 0.916 0.360173   
## z.diff.lag10 0.1445050 0.0456992 3.162 0.001650 \*\*   
## z.diff.lag11 -0.0189810 0.0459103 -0.413 0.679442   
## z.diff.lag12 -0.8183036 0.0458678 -17.840 < 2e-16 \*\*\*  
## z.diff.lag13 0.2392808 0.0545855 4.384 1.39e-05 \*\*\*  
## z.diff.lag14 0.0142541 0.0554560 0.257 0.797244   
## z.diff.lag15 0.0108236 0.0554015 0.195 0.845176   
## z.diff.lag16 0.0258660 0.0553886 0.467 0.640685   
## z.diff.lag17 0.1675536 0.0553228 3.029 0.002568 \*\*   
## z.diff.lag18 0.1101103 0.0557877 1.974 0.048894 \*   
## z.diff.lag19 -0.0717804 0.0560097 -1.282 0.200514   
## z.diff.lag20 0.1207093 0.0561055 2.151 0.031859 \*   
## z.diff.lag21 0.0361437 0.0563446 0.641 0.521472   
## z.diff.lag22 0.1019478 0.0564296 1.807 0.071346 .   
## z.diff.lag23 -0.0616294 0.0566459 -1.088 0.277066   
## z.diff.lag24 -0.6807175 0.0564580 -12.057 < 2e-16 \*\*\*  
## z.diff.lag25 0.2073773 0.0606181 3.421 0.000668 \*\*\*  
## z.diff.lag26 0.0062312 0.0611336 0.102 0.918851   
## z.diff.lag27 0.0391062 0.0611273 0.640 0.522592   
## z.diff.lag28 -0.0137332 0.0611493 -0.225 0.822382   
## z.diff.lag29 0.1666472 0.0611489 2.725 0.006622 \*\*   
## z.diff.lag30 0.0257377 0.0615186 0.418 0.675832   
## z.diff.lag31 -0.0185211 0.0613596 -0.302 0.762880   
## z.diff.lag32 0.0857545 0.0612185 1.401 0.161820   
## z.diff.lag33 0.0844506 0.0613186 1.377 0.168978   
## z.diff.lag34 0.1071429 0.0613969 1.745 0.081509 .   
## z.diff.lag35 -0.0482198 0.0615256 -0.784 0.433521   
## z.diff.lag36 -0.5136332 0.0613994 -8.365 4.63e-16 \*\*\*  
## z.diff.lag37 0.1678752 0.0609736 2.753 0.006089 \*\*   
## z.diff.lag38 0.0008701 0.0613307 0.014 0.988685   
## z.diff.lag39 -0.0064586 0.0613083 -0.105 0.916138   
## z.diff.lag40 0.0144171 0.0613173 0.235 0.814197   
## z.diff.lag41 0.1350929 0.0612305 2.206 0.027761 \*   
## z.diff.lag42 -0.0275638 0.0614760 -0.448 0.654059   
## z.diff.lag43 0.0307693 0.0613306 0.502 0.616076   
## z.diff.lag44 0.0550648 0.0610674 0.902 0.367594   
## z.diff.lag45 0.0211326 0.0610965 0.346 0.729555   
## z.diff.lag46 0.0688726 0.0610099 1.129 0.259425   
## z.diff.lag47 -0.0401797 0.0610776 -0.658 0.510902   
## z.diff.lag48 -0.3924735 0.0607261 -6.463 2.21e-10 \*\*\*  
## z.diff.lag49 0.1293969 0.0554883 2.332 0.020050 \*   
## z.diff.lag50 0.0032974 0.0556311 0.059 0.952756   
## z.diff.lag51 -0.0355021 0.0556002 -0.639 0.523389   
## z.diff.lag52 0.0200615 0.0556699 0.360 0.718707   
## z.diff.lag53 0.0303776 0.0555102 0.547 0.584425   
## z.diff.lag54 -0.0049795 0.0554158 -0.090 0.928432   
## z.diff.lag55 0.0164501 0.0552671 0.298 0.766081   
## z.diff.lag56 0.1039972 0.0550674 1.889 0.059461 .   
## z.diff.lag57 0.0064279 0.0552258 0.116 0.907382   
## z.diff.lag58 0.0571294 0.0552555 1.034 0.301615   
## z.diff.lag59 0.0382828 0.0553159 0.692 0.489172   
## z.diff.lag60 -0.3779845 0.0546431 -6.917 1.24e-11 \*\*\*  
## z.diff.lag61 0.0779464 0.0442934 1.760 0.078982 .   
## z.diff.lag62 -0.0594768 0.0443457 -1.341 0.180387   
## z.diff.lag63 0.0538230 0.0441303 1.220 0.223107   
## z.diff.lag64 -0.0777658 0.0441636 -1.761 0.078798 .   
## z.diff.lag65 0.0557824 0.0442063 1.262 0.207513   
## z.diff.lag66 0.0070194 0.0442070 0.159 0.873895   
## z.diff.lag67 -0.0383518 0.0439888 -0.872 0.383655   
## z.diff.lag68 0.0164713 0.0439168 0.375 0.707757   
## z.diff.lag69 0.0038711 0.0439176 0.088 0.929793   
## z.diff.lag70 0.0070129 0.0437767 0.160 0.872783   
## z.diff.lag71 0.0691558 0.0437841 1.579 0.114782   
## z.diff.lag72 -0.1847393 0.0416949 -4.431 1.13e-05 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01098 on 570 degrees of freedom  
## Multiple R-squared: 0.5748, Adjusted R-squared: 0.5203   
## F-statistic: 10.56 on 73 and 570 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.2923 2.6297   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau2 -3.43 -2.86 -2.57  
## phi1 6.43 4.59 3.78

ur.df(diff(ur\_test,12),type = 'drift',lags = 100 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression drift   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.036382 -0.006060 -0.000035 0.005513 0.050121   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.005527 0.001883 2.935 0.003476 \*\*   
## z.lag.1 -0.049431 0.016602 -2.977 0.003036 \*\*   
## z.diff.lag1 0.396152 0.043876 9.029 < 2e-16 \*\*\*  
## z.diff.lag2 -0.013706 0.047088 -0.291 0.771113   
## z.diff.lag3 0.094730 0.046976 2.017 0.044230 \*   
## z.diff.lag4 0.098097 0.047208 2.078 0.038178 \*   
## z.diff.lag5 0.090737 0.047339 1.917 0.055793 .   
## z.diff.lag6 0.206970 0.046160 4.484 8.95e-06 \*\*\*  
## z.diff.lag7 -0.088153 0.046965 -1.877 0.061053 .   
## z.diff.lag8 0.137090 0.047086 2.911 0.003744 \*\*   
## z.diff.lag9 0.035524 0.047374 0.750 0.453663   
## z.diff.lag10 0.157216 0.046996 3.345 0.000879 \*\*\*  
## z.diff.lag11 0.016552 0.047036 0.352 0.725050   
## z.diff.lag12 -0.824852 0.046925 -17.578 < 2e-16 \*\*\*  
## z.diff.lag13 0.309635 0.058671 5.278 1.89e-07 \*\*\*  
## z.diff.lag14 -0.010440 0.060009 -0.174 0.861952   
## z.diff.lag15 0.051574 0.059994 0.860 0.390363   
## z.diff.lag16 0.054049 0.059800 0.904 0.366485   
## z.diff.lag17 0.166881 0.058750 2.841 0.004672 \*\*   
## z.diff.lag18 0.161020 0.055718 2.890 0.004007 \*\*   
## z.diff.lag19 -0.120180 0.056153 -2.140 0.032779 \*   
## z.diff.lag20 0.142069 0.056386 2.520 0.012034 \*   
## z.diff.lag21 0.019278 0.056593 0.341 0.733506   
## z.diff.lag22 0.123378 0.056362 2.189 0.029018 \*   
## z.diff.lag23 -0.041303 0.056348 -0.733 0.463875   
## z.diff.lag24 -0.677560 0.056058 -12.087 < 2e-16 \*\*\*  
## z.diff.lag25 0.261297 0.063109 4.140 4.02e-05 \*\*\*  
## z.diff.lag26 -0.012918 0.064055 -0.202 0.840250   
## z.diff.lag27 0.082203 0.063976 1.285 0.199367   
## z.diff.lag28 -0.007625 0.063984 -0.119 0.905188   
## z.diff.lag29 0.191416 0.063422 3.018 0.002662 \*\*   
## z.diff.lag30 0.070208 0.060596 1.159 0.247111   
## z.diff.lag31 -0.046385 0.060599 -0.765 0.444340   
## z.diff.lag32 0.109975 0.060625 1.814 0.070227 .   
## z.diff.lag33 0.041778 0.060792 0.687 0.492224   
## z.diff.lag34 0.167070 0.060661 2.754 0.006081 \*\*   
## z.diff.lag35 -0.055662 0.060736 -0.916 0.359828   
## z.diff.lag36 -0.524949 0.060586 -8.664 < 2e-16 \*\*\*  
## z.diff.lag37 0.202389 0.064426 3.141 0.001773 \*\*   
## z.diff.lag38 0.001447 0.065018 0.022 0.982251   
## z.diff.lag39 0.018793 0.065026 0.289 0.772686   
## z.diff.lag40 0.015270 0.065032 0.235 0.814452   
## z.diff.lag41 0.193823 0.064733 2.994 0.002877 \*\*   
## z.diff.lag42 -0.007640 0.060486 -0.126 0.899533   
## z.diff.lag43 0.024532 0.060413 0.406 0.684842   
## z.diff.lag44 0.038463 0.060290 0.638 0.523758   
## z.diff.lag45 -0.008107 0.060310 -0.134 0.893122   
## z.diff.lag46 0.117999 0.060273 1.958 0.050768 .   
## z.diff.lag47 -0.071761 0.060426 -1.188 0.235511   
## z.diff.lag48 -0.380917 0.060450 -6.301 6.09e-10 \*\*\*  
## z.diff.lag49 0.139607 0.062261 2.242 0.025344 \*   
## z.diff.lag50 0.051915 0.062501 0.831 0.406552   
## z.diff.lag51 -0.021833 0.062393 -0.350 0.726525   
## z.diff.lag52 0.033610 0.062401 0.539 0.590376   
## z.diff.lag53 0.116800 0.061957 1.885 0.059937 .   
## z.diff.lag54 0.004370 0.054383 0.080 0.935984   
## z.diff.lag55 0.017724 0.054227 0.327 0.743901   
## z.diff.lag56 0.072202 0.054182 1.333 0.183231   
## z.diff.lag57 -0.001216 0.054232 -0.022 0.982118   
## z.diff.lag58 0.074272 0.054204 1.370 0.171178   
## z.diff.lag59 0.026363 0.054173 0.487 0.626710   
## z.diff.lag60 -0.389927 0.054133 -7.203 1.97e-12 \*\*\*  
## z.diff.lag61 0.104906 0.056321 1.863 0.063048 .   
## z.diff.lag62 -0.007019 0.056535 -0.124 0.901242   
## z.diff.lag63 0.047649 0.056400 0.845 0.398571   
## z.diff.lag64 -0.045118 0.056446 -0.799 0.424453   
## z.diff.lag65 0.123275 0.055840 2.208 0.027684 \*   
## z.diff.lag66 0.024468 0.043399 0.564 0.573128   
## z.diff.lag67 -0.063838 0.043312 -1.474 0.141087   
## z.diff.lag68 0.008675 0.043170 0.201 0.840819   
## z.diff.lag69 -0.009672 0.043167 -0.224 0.822803   
## z.diff.lag70 0.014244 0.043135 0.330 0.741364   
## z.diff.lag71 0.045994 0.043130 1.066 0.286709   
## z.diff.lag72 -0.202284 0.042931 -4.712 3.12e-06 \*\*\*  
## z.diff.lag73 0.022619 0.043631 0.518 0.604382   
## z.diff.lag74 0.043799 0.043682 1.003 0.316469   
## z.diff.lag75 0.001262 0.043581 0.029 0.976911   
## z.diff.lag76 0.039230 0.043606 0.900 0.368703   
## z.diff.lag77 0.079058 0.041645 1.898 0.058174 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.01058 on 545 degrees of freedom  
## Multiple R-squared: 0.5979, Adjusted R-squared: 0.5403   
## F-statistic: 10.39 on 78 and 545 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.9774 4.4439   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau2 -3.43 -2.86 -2.57  
## phi1 6.43 4.59 3.78

*Optimum number of lags is 77*

*ADF for seasonal unit root*

ur.df(diff(ur\_test,12),type = 'drift',lags = 77 , selectlags = "AIC")%>%summary()

##   
## ###############################################   
## # Augmented Dickey-Fuller Test Unit Root Test #   
## ###############################################   
##   
## Test regression drift   
##   
##   
## Call:  
## lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.035811 -0.006200 0.000107 0.005863 0.052198   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.0039295 0.0018490 2.125 0.033996 \*   
## z.lag.1 -0.0359969 0.0164215 -2.192 0.028777 \*   
## z.diff.lag1 0.3483406 0.0424989 8.196 1.63e-15 \*\*\*  
## z.diff.lag2 -0.0030101 0.0449356 -0.067 0.946616   
## z.diff.lag3 0.0792145 0.0449298 1.763 0.078421 .   
## z.diff.lag4 0.0494407 0.0450833 1.097 0.273253   
## z.diff.lag5 0.1100904 0.0451544 2.438 0.015068 \*   
## z.diff.lag6 0.1506923 0.0453083 3.326 0.000938 \*\*\*  
## z.diff.lag7 -0.0393377 0.0457114 -0.861 0.389837   
## z.diff.lag8 0.0959522 0.0457490 2.097 0.036399 \*   
## z.diff.lag9 0.0423725 0.0456595 0.928 0.353792   
## z.diff.lag10 0.1410996 0.0457275 3.086 0.002129 \*\*   
## z.diff.lag11 -0.0196365 0.0459661 -0.427 0.669397   
## z.diff.lag12 -0.8167517 0.0459309 -17.782 < 2e-16 \*\*\*  
## z.diff.lag13 0.2329573 0.0545807 4.268 2.31e-05 \*\*\*  
## z.diff.lag14 0.0138839 0.0553478 0.251 0.802021   
## z.diff.lag15 0.0086427 0.0553721 0.156 0.876022   
## z.diff.lag16 0.0214085 0.0554057 0.386 0.699348   
## z.diff.lag17 0.1652091 0.0554247 2.981 0.002997 \*\*   
## z.diff.lag18 0.1110838 0.0558787 1.988 0.047293 \*   
## z.diff.lag19 -0.0762921 0.0560853 -1.360 0.174274   
## z.diff.lag20 0.1150627 0.0561201 2.050 0.040790 \*   
## z.diff.lag21 0.0424997 0.0562322 0.756 0.450086   
## z.diff.lag22 0.0913309 0.0562888 1.623 0.105237   
## z.diff.lag23 -0.0577495 0.0565686 -1.021 0.307744   
## z.diff.lag24 -0.6853215 0.0564898 -12.132 < 2e-16 \*\*\*  
## z.diff.lag25 0.2047839 0.0607259 3.372 0.000796 \*\*\*  
## z.diff.lag26 0.0039548 0.0611959 0.065 0.948495   
## z.diff.lag27 0.0366005 0.0611872 0.598 0.549961   
## z.diff.lag28 -0.0084250 0.0610492 -0.138 0.890287   
## z.diff.lag29 0.1658564 0.0610557 2.716 0.006797 \*\*   
## z.diff.lag30 0.0287230 0.0614198 0.468 0.640212   
## z.diff.lag31 -0.0181885 0.0614264 -0.296 0.767260   
## z.diff.lag32 0.0807737 0.0612821 1.318 0.188009   
## z.diff.lag33 0.0844530 0.0614076 1.375 0.169580   
## z.diff.lag34 0.0974707 0.0613644 1.588 0.112750   
## z.diff.lag35 -0.0465789 0.0614910 -0.757 0.449067   
## z.diff.lag36 -0.5229678 0.0613360 -8.526 < 2e-16 \*\*\*  
## z.diff.lag37 0.1684251 0.0610907 2.757 0.006020 \*\*   
## z.diff.lag38 -0.0073244 0.0613079 -0.119 0.904946   
## z.diff.lag39 -0.0055333 0.0612953 -0.090 0.928102   
## z.diff.lag40 0.0171578 0.0611115 0.281 0.778995   
## z.diff.lag41 0.1326899 0.0611579 2.170 0.030445 \*   
## z.diff.lag42 -0.0207903 0.0613879 -0.339 0.734982   
## z.diff.lag43 0.0240523 0.0613600 0.392 0.695214   
## z.diff.lag44 0.0561842 0.0611070 0.919 0.358253   
## z.diff.lag45 0.0152006 0.0611343 0.249 0.803726   
## z.diff.lag46 0.0620413 0.0610001 1.017 0.309550   
## z.diff.lag47 -0.0403559 0.0610504 -0.661 0.508861   
## z.diff.lag48 -0.3971273 0.0606883 -6.544 1.33e-10 \*\*\*  
## z.diff.lag49 0.1269476 0.0555807 2.284 0.022735 \*   
## z.diff.lag50 0.0009086 0.0556428 0.016 0.986977   
## z.diff.lag51 -0.0358291 0.0556199 -0.644 0.519718   
## z.diff.lag52 0.0203638 0.0556601 0.366 0.714604   
## z.diff.lag53 0.0328501 0.0555401 0.591 0.554442   
## z.diff.lag54 -0.0035927 0.0554418 -0.065 0.948354   
## z.diff.lag55 0.0174611 0.0553578 0.315 0.752555   
## z.diff.lag56 0.1029158 0.0551702 1.865 0.062633 .   
## z.diff.lag57 0.0033697 0.0553173 0.061 0.951448   
## z.diff.lag58 0.0524865 0.0552713 0.950 0.342708   
## z.diff.lag59 0.0358128 0.0553150 0.647 0.517611   
## z.diff.lag60 -0.3795550 0.0546382 -6.947 1.02e-11 \*\*\*  
## z.diff.lag61 0.0751734 0.0443555 1.695 0.090658 .   
## z.diff.lag62 -0.0610221 0.0443353 -1.376 0.169243   
## z.diff.lag63 0.0533171 0.0441525 1.208 0.227711   
## z.diff.lag64 -0.0777874 0.0441844 -1.761 0.078853 .   
## z.diff.lag65 0.0556877 0.0442546 1.258 0.208779   
## z.diff.lag66 0.0086945 0.0442472 0.196 0.844290   
## z.diff.lag67 -0.0380104 0.0440764 -0.862 0.388842   
## z.diff.lag68 0.0133747 0.0439862 0.304 0.761188   
## z.diff.lag69 0.0039593 0.0439872 0.090 0.928311   
## z.diff.lag70 0.0026490 0.0438183 0.060 0.951815   
## z.diff.lag71 0.0675925 0.0438263 1.542 0.123557   
## z.diff.lag72 -0.1852242 0.0417136 -4.440 1.08e-05 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.011 on 573 degrees of freedom  
## Multiple R-squared: 0.5713, Adjusted R-squared: 0.5167   
## F-statistic: 10.46 on 73 and 573 DF, p-value: < 2.2e-16  
##   
##   
## Value of test-statistic is: -2.1921 2.4029   
##   
## Critical values for test statistics:   
## 1pct 5pct 10pct  
## tau2 -3.43 -2.86 -2.57  
## phi1 6.43 4.59 3.78

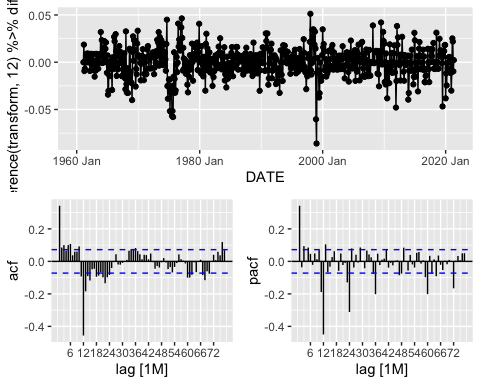
*Here we can see that our test statistics is greater than the critical values for a test size of 1,5 and 10 percent. - 2.1921 > -2.86 therefore, we would fail to reject the null hypothesis here and we can conclude that D=1.*

* Now that we have the appropriate values for D & d , we will have a look at the ACF and the PACF graphs to figure out apprppiate p,q and P,Q values to build an appropriate SARIMA model\*

data\_hold%>%gg\_tsdisplay(difference(transform,12)%>%difference(),lag\_max=77,plot\_type="partial")

## Warning: Removed 13 row(s) containing missing values (geom\_path).

## Warning: Removed 13 rows containing missing values (geom\_point).

 \* Looking at the ACF and PACF we can see that there is a sudden decay in ACF wiht 2 dominating significant coefficients at lags 2 and 12 along with a reasonably important at lag 13. All the other coefficients seems to posses little significance. This pattern of the ACF shows the existance of an MA component and it would be reasonable to take q = 2 . The first lag in the PACF graph seems to be high significance same as the first coefficient from ACF , from this we can take p = 1. Looking further, observation at lags 12,24,36 seem to have high significance and shows a seasonal pattern that diminishes at lag 48 but picks up again at lag 60. Due to this season behavior its reasonable to take P = 3 and since the seasonal component reappears we could expect a season moving average component and will take Q = 1 .\*

* Based on our analysis our appropriate SARIMA model would be a SARIMA(pdq(1,1,2)+PDQ(3,1,1))\*

trials=data\_hold%>%model(   
 m1 = ARIMA(transform~0+pdq(1,1,2)+ PDQ(3,1,1)), #Our Estimated Model  
 m2 = ARIMA(transform~0+pdq(1,1,2)+ PDQ(1,1,1)),#Best Model  
 m3 = ARIMA(transform~0+pdq(3,1,0)+ PDQ(3,1,0)),  
 m4 = ARIMA(transform~0+pdq(3,1,2)+ PDQ(2,1,2)),  
 m5 = ARIMA(transform~0+pdq(3,1,0)+ PDQ(2,1,1)),  
 m6 = ARIMA(transform~0+pdq(3,1,1)+ PDQ(2,1,1))   
 )  
   
glance(trials)

## # A tibble: 6 × 8  
## .model sigma2 log\_lik AIC AICc BIC ar\_roots ma\_roots   
## <chr> <dbl> <dbl> <dbl> <dbl> <dbl> <list> <list>   
## 1 m1 0.000110 2263. -4511. -4511. -4474. <cpl [37]> <cpl [14]>  
## 2 m2 0.000110 2262. -4511. -4511. -4484. <cpl [13]> <cpl [14]>  
## 3 m3 0.000134 2199. -4385. -4385. -4353. <cpl [39]> <cpl [0]>   
## 4 m4 0.000109 2267. -4513. -4513. -4467. <cpl [27]> <cpl [26]>  
## 5 m5 0.000112 2257. -4500. -4499. -4468. <cpl [27]> <cpl [12]>  
## 6 m6 0.000110 2264. -4512. -4512. -4476. <cpl [27]> <cpl [13]>

* Running multiple models to choose the best fit model based on the lowest Value\*
* It looks like a ARIMA(transform~0+pdq(1,1,2)+ PDQ(1,1,1)) would be the best model as it has the lowest BIC value among all 6 , hence this would be a good choice to forecast our data\*

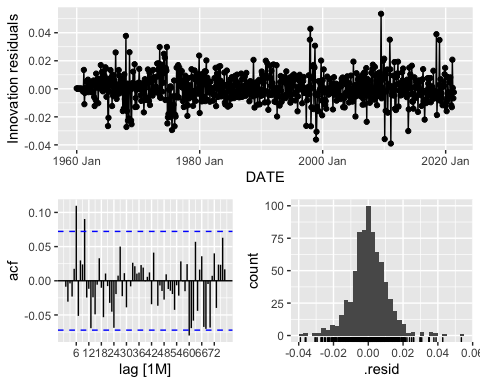
final\_model = data\_hold%>%model(ARIMA(box\_cox(INDCPIALLMINMEI,lambda\_val)  
 ~0+pdq(1,1,2)+ PDQ(1,1,1)))

* Now we will check whether our model was able to consume all the coefficients \*

data\_hold%>%model(ARIMA(transform~0+pdq(1,1,2)+ PDQ(1,1,1)))%>%report()

## Series: transform   
## Model: ARIMA(1,1,2)(1,1,1)[12]   
##   
## Coefficients:  
## ar1 ma1 ma2 sar1 sma1  
## 0.9095 -0.5850 -0.1782 -0.0359 -0.9258  
## s.e. 0.0342 0.0517 0.0406 0.0406 0.0165  
##   
## sigma^2 estimated as 0.0001104: log likelihood=2261.65  
## AIC=-4511.3 AICc=-4511.18 BIC=-4483.79

final\_model%>%gg\_tsresiduals(lag=77)

 *There are 2 sample ACF coefficient at lags 6 & 12 that are statistically significant based on a 5% test size, while the coefficient at lag 60 is marginally significant. It seems that the vast majority of correlation in the data has been absorbed by our model. A more formal Ljung-Box test is needed. Here, we conduct the test that first 77 autocorrelation coefficients are jointly 0.*

*Ljung-Box Test*

augment(final\_model)%>%features(.innov,ljung\_box,lag=77,Dof=5)

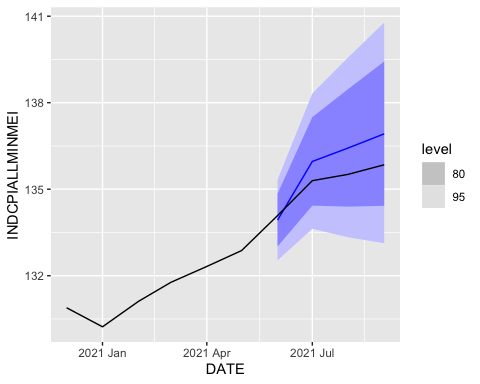
## # A tibble: 1 × 3  
## .model lb\_stat lb\_pvalue  
## <chr> <dbl> <dbl>  
## 1 "ARIMA(box\_cox(INDCPIALLMINMEI, lambda\_val) ~ 0 + pdq(1, 1,… 84.8 0.254

qchisq(0.95,72)

## [1] 92.80827

*On running a Ljung-Box Test the appropiiate distribution is a chi^2(25). The resulting 95% critical value for a chi^2(72) distribution is 84.813 As a result, based on a 5% test-size, we would fail to reject the null hypothesis (84.813<92.80827), concluding that there is less evidence of residual correlation.This model is an appropriate fit to forecast our future data.*

final\_model%>%forecast(h=4)%>%  
 autoplot(filter\_index(data\_tsibble,'2020 Dec' ~ '2021 Oct'))

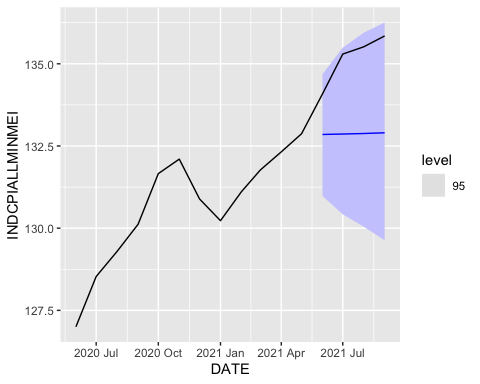


forecast1 = final\_model%>%forecast(h=4)  
filter\_data = filter\_index(data\_tsibble,'2021 Jun' ~'2021 Sep')  
filter\_data\_1 = forecast1%>%as.data.frame%>%select(.mean)  
filter\_data$SARIMA = paste(filter\_data\_1$.mean)   
filter\_data

## # A tsibble: 4 x 3 [1M]  
## DATE INDCPIALLMINMEI SARIMA   
## <mth> <dbl> <chr>   
## 1 2021 Jun 134. 133.927173860109  
## 2 2021 Jul 135. 135.962030111633  
## 3 2021 Aug 136. 136.430025337633  
## 4 2021 Sep 136. 136.919554897168

*MODEL 2*  \* Neural Network \*

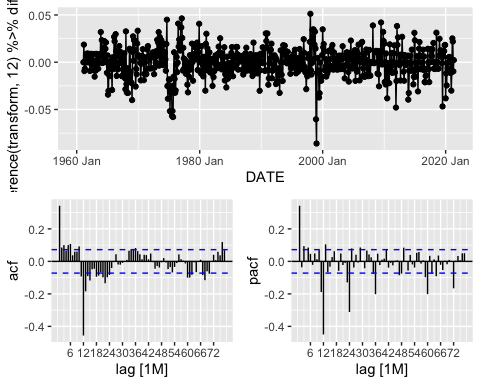
# NEURALAL NET  
#Selecting Auto Regressive components based on the the p & P values of our SARIMA model  
NN1 = data\_hold%>%model(NNETAR(box\_cox(INDCPIALLMINMEI,lambda\_val)~AR(P=1,p=1)))  
NN1%>%forecast(h=4,bootstrap=TRUE)%>%  
 autoplot(data\_tsibble%>%filter\_index('2020 Jun' ~'2021 Sep'),level=95)



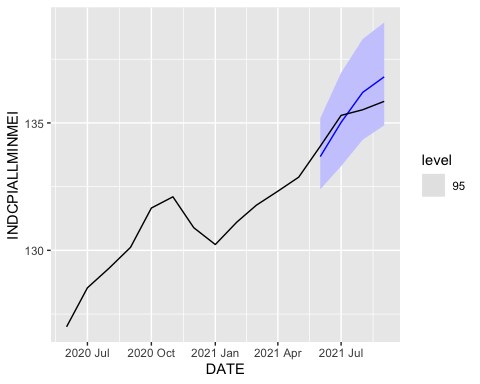
#On observing the PACF plots again we can observer that every coefficient at 12,24,36  
data\_hold%>%gg\_tsdisplay(difference(transform,12)%>%difference(),lag\_max=77,plot\_type="partial")

## Warning: Removed 13 row(s) containing missing values (geom\_path).

## Warning: Removed 13 rows containing missing values (geom\_point).



NN2 = data\_hold%>%model(NNETAR(box\_cox(INDCPIALLMINMEI,lambda\_val)~AR(P=12,p=12)))  
NN2%>%forecast(h=4,bootstrap=TRUE)%>%  
 autoplot(data\_tsibble%>%filter\_index('2020 Jun' ~'2021 Sep'),level=95)



#nn\_forecast =

forecast\_nn = NN2%>%forecast(h=4)  
filter\_data\_nn = forecast\_nn%>%as.data.frame%>%select(.mean)  
filter\_data$Neural\_Network = paste(filter\_data\_nn$.mean)  
filter\_data

## # A tsibble: 4 x 4 [1M]  
## DATE INDCPIALLMINMEI SARIMA Neural\_Network   
## <mth> <dbl> <chr> <chr>   
## 1 2021 Jun 134. 133.927173860109 133.683131331479  
## 2 2021 Jul 135. 135.962030111633 135.029920012095  
## 3 2021 Aug 136. 136.430025337633 136.196465474009  
## 4 2021 Sep 136. 136.919554897168 136.794886884086

remove(list=ls())