Regression

```
library(readxl)
```

```
## Warning: package 'readxl' was built under R version 4.0.5
```

```
Tng_Ctr <- read_excel("C:/Users/prach/Desktop/Rutgers/BF/Project/Tng_Ctr_HourRE.xlsx")
```

Summary of the data

```
class(Tng_Ctr)
```

```
## [1] "tbl_df"     "tbl"        "data.frame"
```

```
summary(Tng_Ctr)
```

```
##      Year             Quarter             Month             Device_Hrs
##  Length:82          Length:82          Length:82          Min.   : 222.8
##  Class :character   Class :character   Class :character   1st Qu.: 900.2
##  Mode  :character   Mode  :character   Mode  :character   Median :1009.1
##                                                           Mean   : 991.9
##                                                           3rd Qu.:1105.5
##                                                           Max.   :1519.9
##
##  Total_Inst_Hrs   Device_Hrs_Sub     Ratio         Holiday_dv
##  Min.   : 504.6   Min.   : 570   Min.   :1.710   Min.   :0.0000
##  1st Qu.:1945.2   1st Qu.: 913   1st Qu.:2.111   1st Qu.:0.0000
##  Median :2209.9   Median :1026   Median :2.186   Median :0.0000
##  Mean   :2169.1   Mean   :1019   Mean   :2.201   Mean   :0.4878
##  3rd Qu.:2445.8   3rd Qu.:1128   3rd Qu.:2.317   3rd Qu.:1.0000
##  Max.   :3084.1   Max.   :1520   Max.   :2.529   Max.   :1.0000
##
##     COVID_dv            RPM               UNRATE
##  Min.   :0.00000   Min.   : 2553492   Min.   : 3.500
##  1st Qu.:0.00000   1st Qu.:52163613   1st Qu.: 4.000
##  Median :0.00000   Median :55929396   Median : 4.700
##  Mean   :0.09756   Mean   :51284108   Mean   : 5.104
##  3rd Qu.:0.00000   3rd Qu.:60277998   3rd Qu.: 5.375
##  Max.   :1.00000   Max.   :64656057   Max.   :14.800
##                    NA's   :2
```

Libraries

```r
library(data.table)
```

```
## Warning: package 'data.table' was built under R version 4.0.5
```

```r
library(fpp3)
```

```
## Warning: package 'fpp3' was built under R version 4.0.5
```

```
## -- Attaching packages --------------------------------------- fpp3 0.4.0 --
```

```
## v tibble      3.1.4      v tsibble     1.0.1
## v dplyr       1.0.7      v tsibbledata 0.3.0
## v tidyr       1.1.4      v feasts      0.2.2
## v lubridate   1.7.10     v fable       0.3.1
## v ggplot2     3.3.5
```

```
## Warning: package 'tibble' was built under R version 4.0.5
```

```
## Warning: package 'dplyr' was built under R version 4.0.5
```

```
## Warning: package 'tidyr' was built under R version 4.0.5
```

```
## Warning: package 'lubridate' was built under R version 4.0.5
```

```
## Warning: package 'ggplot2' was built under R version 4.0.5
```

```
## Warning: package 'tsibble' was built under R version 4.0.5
```

```
## Warning: package 'tsibbledata' was built under R version 4.0.5
```

```
## Warning: package 'feasts' was built under R version 4.0.5
```

```
## Warning: package 'fabletools' was built under R version 4.0.5
```

```
## Warning: package 'fable' was built under R version 4.0.5
```

```
## -- Conflicts ------------------------------------------ fpp3_conflicts --
## x dplyr::between()     masks data.table::between()
## x lubridate::date()    masks base::date()
## x dplyr::filter()      masks stats::filter()
## x dplyr::first()       masks data.table::first()
## x lubridate::hour()    masks data.table::hour()
## x tsibble::intersect() masks base::intersect()
## x tsibble::interval()  masks lubridate::interval()
## x lubridate::isoweek() masks data.table::isoweek()
## x tsibble::key()       masks data.table::key()
## x dplyr::lag()         masks stats::lag()
## x dplyr::last()        masks data.table::last()
```

```
## x lubridate::mday()    masks data.table::mday()
## x lubridate::minute()  masks data.table::minute()
## x lubridate::month()   masks data.table::month()
## x lubridate::quarter() masks data.table::quarter()
## x lubridate::second()  masks data.table::second()
## x tsibble::setdiff()   masks base::setdiff()
## x tsibble::union()     masks base::union()
## x lubridate::wday()    masks data.table::wday()
## x lubridate::week()    masks data.table::week()
## x lubridate::yday()    masks data.table::yday()
## x lubridate::year()    masks data.table::year()
```

```
library(TTR)
```

```
## Warning: package 'TTR' was built under R version 4.0.5
```

```
library(ggplot2)
library(tsibble)
library(tsibbledata)
library(dplyr)
library(forecast)
```

```
## Warning: package 'forecast' was built under R version 4.0.5
```

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

```
library(fpp)
```

```
## Warning: package 'fpp' was built under R version 4.0.5
```

```
## Loading required package: fma
```

```
## Warning: package 'fma' was built under R version 4.0.5
```

```
## Loading required package: expsmooth
```

```
## Warning: package 'expsmooth' was built under R version 4.0.5
```

```
## Loading required package: lmtest
```

```
## Warning: package 'lmtest' was built under R version 4.0.5
```

```
## Loading required package: zoo
```

```
## Warning: package 'zoo' was built under R version 4.0.5
```

```
##
## Attaching package: 'zoo'
```

```
## The following object is masked from 'package:tsibble':
##
##     index

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

## Loading required package: tseries

## Warning: package 'tseries' was built under R version 4.0.5

##
## Attaching package: 'fpp'

## The following object is masked from 'package:fpp3':
##
##     insurance
```

```
library(fpp2)
```

```
## Warning: package 'fpp2' was built under R version 4.0.5

##
## Attaching package: 'fpp2'

## The following objects are masked from 'package:fpp':
##
##     ausair, ausbeer, austa, austourists, debitcards, departures,
##     elecequip, euretail, guinearice, oil, sunspotarea, usmelec

## The following object is masked from 'package:fpp3':
##
##     insurance
```

```
library(bsts)
```

```
## Warning: package 'bsts' was built under R version 4.0.5

## Loading required package: BoomSpikeSlab

## Warning: package 'BoomSpikeSlab' was built under R version 4.0.5

## Loading required package: Boom

## Warning: package 'Boom' was built under R version 4.0.5

## Loading required package: MASS
```

```
##
## Attaching package: 'MASS'

## The following objects are masked from 'package:fma':
##
##     cement, housing, petrol

## The following object is masked from 'package:dplyr':
##
##     select

##
## Attaching package: 'Boom'

## The following object is masked from 'package:stats':
##
##     rWishart

##
## Attaching package: 'BoomSpikeSlab'

## The following object is masked from 'package:stats':
##
##     knots

## Loading required package: xts

## Warning: package 'xts' was built under R version 4.0.5

##
## Attaching package: 'xts'

## The following objects are masked from 'package:dplyr':
##
##     first, last

## The following objects are masked from 'package:data.table':
##
##     first, last

##
## Attaching package: 'bsts'

## The following object is masked from 'package:BoomSpikeSlab':
##
##     SuggestBurn
```

```
library(prophet)
```

```
## Warning: package 'prophet' was built under R version 4.0.5
```

```
## Loading required package: Rcpp

## Warning: package 'Rcpp' was built under R version 4.0.5

## Loading required package: rlang

## Warning: package 'rlang' was built under R version 4.0.5

##
## Attaching package: 'rlang'

## The following object is masked from 'package:data.table':
##
##     :=
```

```
library(repr)
```

```
## Warning: package 'repr' was built under R version 4.0.5
```

```
library(GGally)
```

```
## Warning: package 'GGally' was built under R version 4.0.5

## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2

##
## Attaching package: 'GGally'

## The following object is masked from 'package:fma':
##
##     pigs
```

```
Tng = Tng_Ctr[,c(1,2,3,4,8,9,10,11)]
summary(Tng)
```

```
##      Year             Quarter             Month             Device_Hrs
##  Length:82          Length:82          Length:82          Min.   : 222.8
##  Class :character   Class :character   Class :character   1st Qu.: 900.2
##  Mode  :character   Mode  :character   Mode  :character   Median :1009.1
##                                                           Mean   : 991.9
##                                                           3rd Qu.:1105.5
##                                                           Max.   :1519.9
##
##    Holiday_dv        COVID_dv            RPM               UNRATE
##  Min.   :0.0000   Min.   :0.00000   Min.   : 2553492   Min.   : 3.500
##  1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:52163613   1st Qu.: 4.000
##  Median :0.0000   Median :0.00000   Median :55929396   Median : 4.700
##  Mean   :0.4878   Mean   :0.09756   Mean   :51284108   Mean   : 5.104
##  3rd Qu.:1.0000   3rd Qu.:0.00000   3rd Qu.:60277998   3rd Qu.: 5.375
##  Max.   :1.0000   Max.   :1.00000   Max.   :64656057   Max.   :14.800
##                                     NA's   :2
```

```
Tng = na.omit(Tng)
summary(Tng)
```

```
##      Year             Quarter             Month             Device_Hrs
##  Length:80          Length:80          Length:80          Min.   : 222.8
##  Class :character   Class :character   Class :character   1st Qu.: 892.9
##  Mode  :character   Mode  :character   Mode  :character   Median :1004.8
##                                                           Mean   : 989.9
##                                                           3rd Qu.:1103.0
##                                                           Max.   :1519.9
##    Holiday_dv        COVID_dv        RPM               UNRATE
##  Min.   :0.0000   Min.   :0.0   Min.   : 2553492   Min.   : 3.500
##  1st Qu.:0.0000   1st Qu.:0.0   1st Qu.:52163613   1st Qu.: 3.975
##  Median :0.0000   Median :0.0   Median :55929396   Median : 4.700
##  Mean   :0.4875   Mean   :0.1   Mean   :51284108   Mean   : 5.114
##  3rd Qu.:1.0000   3rd Qu.:0.0   3rd Qu.:60277998   3rd Qu.: 5.400
##  Max.   :1.0000   Max.   :1.0   Max.   :64656057   Max.   :14.800
```

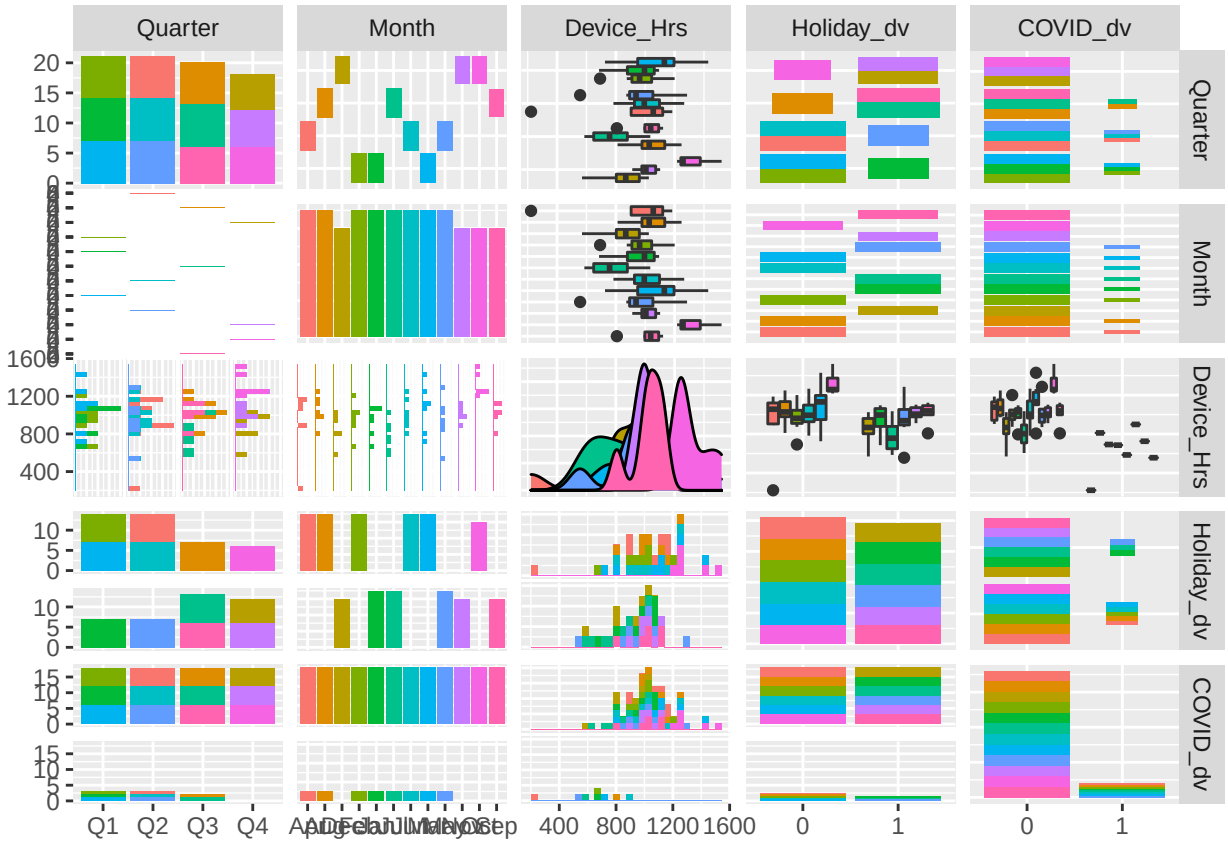
RPM is Revenue Passenger Miles for US Domestic Air Carriers.Unrate is an unemployment rate of USA.

```
setDT(Tng)
Tng[,Year:=factor(Year)]
Tng[,Quarter:=factor(Quarter)]
Tng[,Month:=factor(Month)]
Tng[,Holiday_dv:=factor(Holiday_dv, levels = c(0,1))]
Tng[,COVID_dv:=factor(COVID_dv, levels = c(0,1))]
summary(Tng)
```

```
##       Year    Quarter     Month      Device_Hrs     Holiday_dv COVID_dv
##  2015-01: 1   Q1:21   Apr    : 7   Min.   : 222.8   0:41       0:72
##  2015-02: 1   Q2:21   Aug    : 7   1st Qu.: 892.9   1:39       1: 8
##  2015-03: 1   Q3:20   Feb    : 7   Median :1004.8
##  2015-04: 1   Q4:18   Jan    : 7   Mean   : 989.9
##  2015-05: 1           Jul    : 7   3rd Qu.:1103.0
##  2015-06: 1           Jun    : 7   Max.   :1519.9
##  (Other):74           (Other):38
##       RPM               UNRATE
##  Min.   : 2553492   Min.   : 3.500
##  1st Qu.:52163613   1st Qu.: 3.975
##  Median :55929396   Median : 4.700
##  Mean   :51284108   Mean   : 5.114
##  3rd Qu.:60277998   3rd Qu.: 5.400
##  Max.   :64656057   Max.   :14.800
##
```

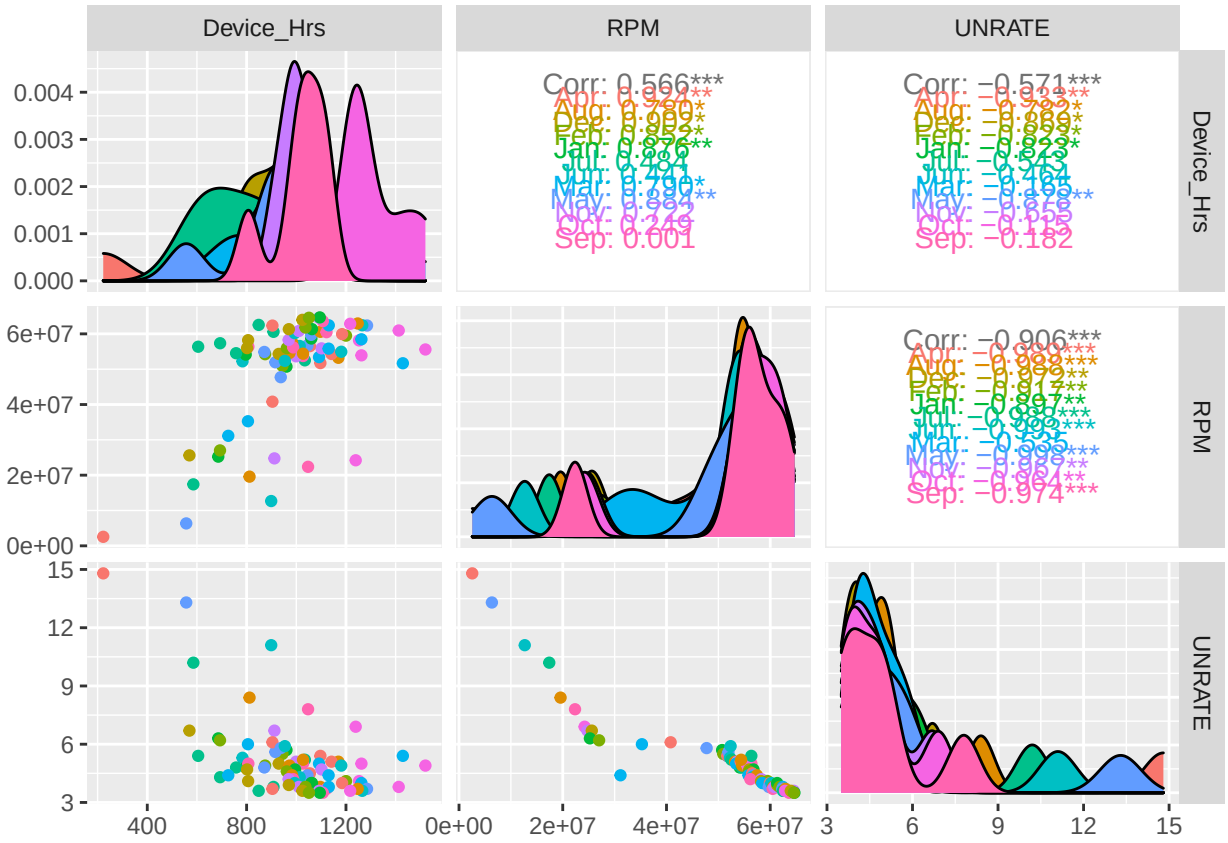
```
ggpairs(Tng, c(2:6), mapping = aes(colour = Month))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



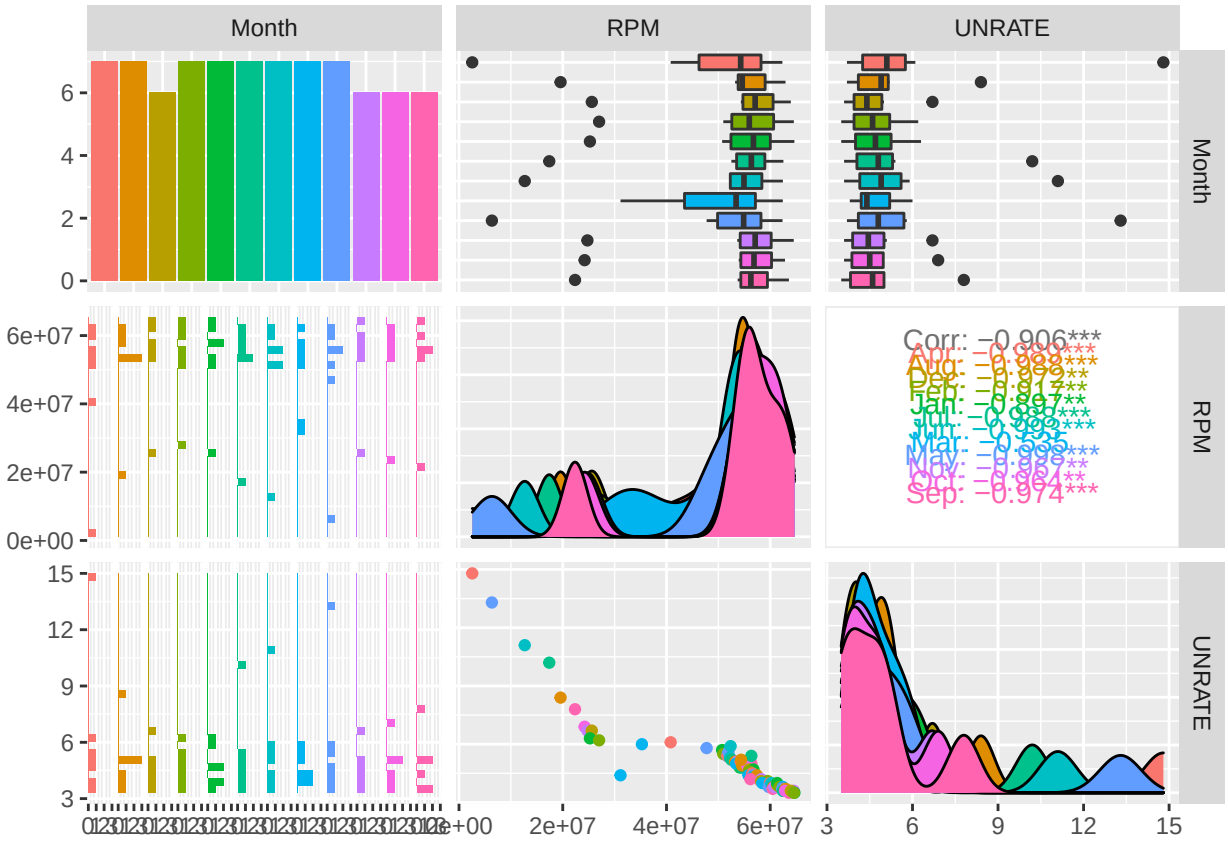
Here, we can see that there is an interaction between Month and RPM and Month and device_hrs. The months heavily affected by Covid outbreaks also affected by the Device Hours.

```
ggpairs(Tng, c(4,7,8), mapping = aes(colour = Month))
```

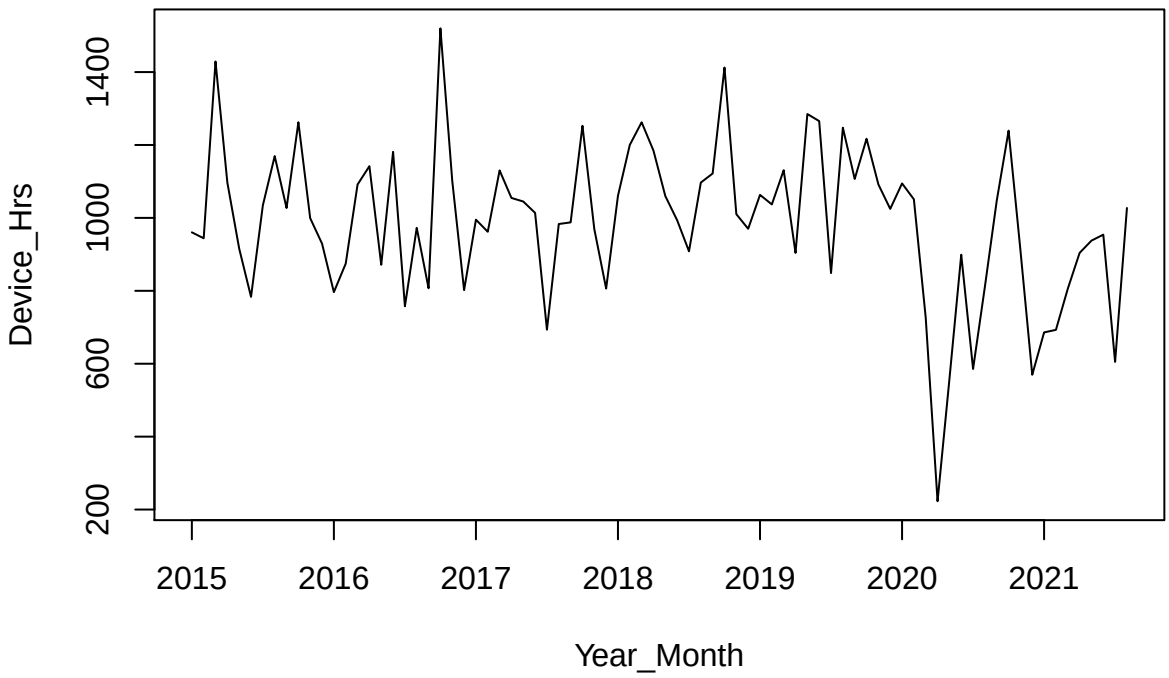



```
ggpairs(Tng, c(3,7,8), mapping = aes(colour = Month))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
Tng_ts = ts(Tng$Device_Hrs, frequency=12, start=c(2015,1))
plot(Tng_ts, xlab = "Year_Month", ylab = "Device_Hrs")
```



Building a model with interaction of Month and RPM and Month and Unemployment Rate:

```
fit.Tng = lm(Device_Hrs ~ Month + COVID_dv + RPM +UNRATE + Month:RPM +Month:UNRATE, data = Tng)
summary(fit.Tng)
```

```
##
## Call:
## lm(formula = Device_Hrs ~ Month + COVID_dv + RPM + UNRATE + Month:RPM +
##     Month:UNRATE, data = Tng)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -249.182  -59.578   -0.039   54.176  296.593
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.081e+03  1.438e+03   1.447   0.1552
## MonthAug        -2.615e+03  3.050e+03  -0.857   0.3961
## MonthDec        -1.955e+03  2.350e+03  -0.832   0.4101
## MonthFeb        -2.961e+03  2.417e+03  -1.225   0.2273
## MonthJan        -2.775e+03  2.213e+03  -1.254   0.2166
## MonthJul         2.100e+02  2.561e+03   0.082   0.9350
```

```
## MonthJun        -9.310e+02  2.892e+03  -0.322   0.7491
## MonthMar        -3.800e+03  2.013e+03  -1.888   0.0657 .
## MonthMay        -2.719e+03  4.063e+03  -0.669   0.5070
## MonthNov        -1.617e+03  2.214e+03  -0.730   0.4691
## MonthOct        -2.491e+03  2.137e+03  -1.166   0.2500
## MonthSep         1.593e+03  2.166e+03   0.736   0.4660
## COVID_dv1        3.512e+02  2.451e+02   1.433   0.1591
## RPM             -6.205e-06  1.750e-05  -0.355   0.7247
## UNRATE          -1.461e+02  1.030e+02  -1.419   0.1632
## MonthAug:RPM     2.944e-05  3.375e-05   0.872   0.3879
## MonthDec:RPM     1.820e-05  2.426e-05   0.750   0.4571
## MonthFeb:RPM     3.263e-05  2.670e-05   1.222   0.2282
## MonthJan:RPM     3.045e-05  2.494e-05   1.221   0.2289
## MonthJul:RPM    -5.798e-06  3.043e-05  -0.190   0.8498
## MonthJun:RPM     9.146e-06  3.428e-05   0.267   0.7909
## MonthMar:RPM     3.878e-05  2.219e-05   1.747   0.0877 .
## MonthMay:RPM     3.184e-05  4.950e-05   0.643   0.5235
## MonthNov:RPM     1.299e-05  2.313e-05   0.561   0.5774
## MonthOct:RPM     2.298e-05  2.287e-05   1.005   0.3206
## MonthSep:RPM    -2.042e-05  2.407e-05  -0.848   0.4011
## MonthAug:UNRATE  2.100e+02  2.558e+02   0.821   0.4162
## MonthDec:UNRATE  1.645e+02  2.333e+02   0.705   0.4846
## MonthFeb:UNRATE  2.286e+02  2.115e+02   1.081   0.2857
## MonthJan:UNRATE  2.115e+02  1.870e+02   1.131   0.2642
## MonthJul:UNRATE -3.128e+01  1.860e+02  -0.168   0.8672
## MonthJun:UNRATE  8.623e+01  2.095e+02   0.412   0.6827
## MonthMar:UNRATE  3.861e+02  1.827e+02   2.113   0.0404 *
## MonthMay:UNRATE  1.963e+02  2.811e+02   0.698   0.4888
## MonthNov:UNRATE  1.870e+02  2.173e+02   0.861   0.3941
## MonthOct:UNRATE  3.254e+02  2.019e+02   1.612   0.1143
## MonthSep:UNRATE -1.149e+02  1.885e+02  -0.610   0.5453
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 124.4 on 43 degrees of freedom
## Multiple R-squared:  0.8135, Adjusted R-squared:  0.6574
## F-statistic: 5.211 on 36 and 43 DF,  p-value: 2.881e-07
```

Stepwise Regression

```
step(fit.Tng)
```

```
## Start:  AIC=796.11
## Device_Hrs ~ Month + COVID_dv + RPM + UNRATE + Month:RPM + Month:UNRATE
##
##                Df Sum of Sq    RSS    AIC
## - Month:UNRATE 11    174779 840325 792.76
## <none>                      665546 796.11
## - COVID_dv      1     31776 697322 797.84
## - Month:RPM    11    235402 900948 798.33
##
## Step:  AIC=792.76
## Device_Hrs ~ Month + COVID_dv + RPM + UNRATE + Month:RPM
```

```
##
##             Df Sum of Sq     RSS    AIC
## - COVID_dv   1       442  840768 790.80
## - UNRATE     1      3042  843368 791.05
## <none>                    840325 792.76
## - Month:RPM 11    311144 1151469 795.96
##
## Step:  AIC=790.8
## Device_Hrs ~ Month + RPM + UNRATE + Month:RPM
##
##             Df Sum of Sq     RSS    AIC
## - UNRATE     1      2623  843390 789.05
## <none>                    840768 790.80
## - Month:RPM 11    350753 1191520 796.70
##
## Step:  AIC=789.05
## Device_Hrs ~ Month + RPM + Month:RPM
##
##             Df Sum of Sq     RSS    AIC
## <none>                    843390 789.05
## - Month:RPM 11    365052 1208442 795.83
```

```
##
## Call:
## lm(formula = Device_Hrs ~ Month + RPM + Month:RPM, data = Tng)
##
## Coefficients:
##  (Intercept)      MonthAug      MonthDec      MonthFeb      MonthJan
##    2.399e+02     4.095e+02     4.802e+01     1.505e+02     1.662e+02
##     MonthJul      MonthJun      MonthMar      MonthMay      MonthNov
##    2.705e+02     5.589e+02     3.066e+01     2.178e+02     5.805e+02
##     MonthOct      MonthSep           RPM  MonthAug:RPM  MonthDec:RPM
##    9.664e+02     7.760e+02     1.472e-05    -7.099e-06    -4.151e-06
## MonthFeb:RPM  MonthJan:RPM  MonthJul:RPM  MonthJun:RPM  MonthMar:RPM
##   -3.943e-06    -4.452e-06    -9.566e-06    -1.045e-05     1.602e-06
## MonthMay:RPM  MonthNov:RPM  MonthOct:RPM  MonthSep:RPM
##   -4.509e-06    -1.106e-05    -1.261e-05    -1.471e-05
```

Summary of Stepwise model

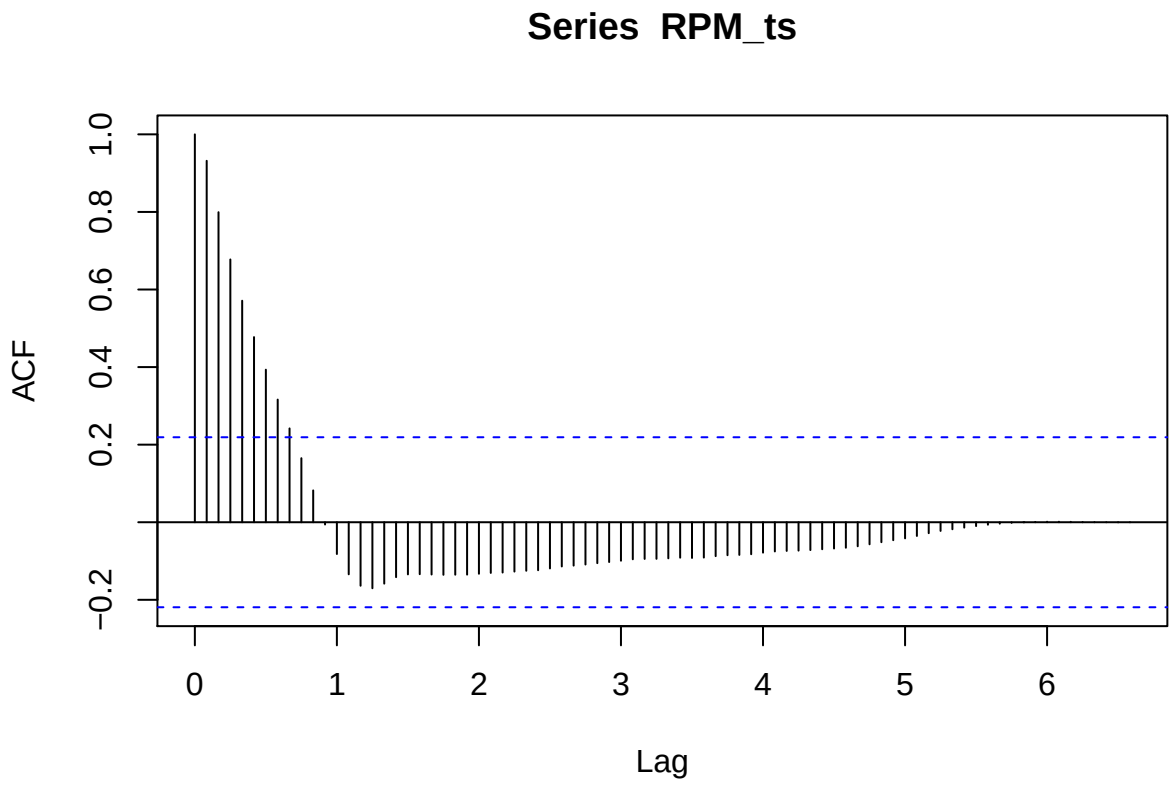
```
fit.step = tslm(Tng_ts ~ Month + RPM + Month:RPM, data = Tng)
summary(fit.step)
```

```
##
## Call:
## tslm(formula = Tng_ts ~ Month + RPM + Month:RPM, data = Tng)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -253.364  -55.428   -3.131   54.333  315.267
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)   2.399e+02  1.223e+02   1.961 0.054896 .
## MonthAug      4.095e+02  2.203e+02   1.859 0.068312 .
## MonthDec      4.802e+01  2.473e+02   0.194 0.846735
## MonthFeb      1.505e+02  2.505e+02   0.601 0.550580
## MonthJan      1.662e+02  2.416e+02   0.688 0.494244
## MonthJul      2.705e+02  2.123e+02   1.274 0.207898
## MonthJun      5.589e+02  1.976e+02   2.828 0.006494 **
## MonthMar      3.066e+01  2.472e+02   0.124 0.901748
## MonthMay      2.178e+02  1.820e+02   1.197 0.236415
## MonthNov      5.805e+02  2.421e+02   2.398 0.019830 *
## MonthOct      9.664e+02  2.414e+02   4.003 0.000186 ***
## MonthSep      7.760e+02  2.321e+02   3.343 0.001481 **
## RPM           1.472e-05  2.415e-06   6.094 1.07e-07 ***
## MonthAug:RPM -7.099e-06  4.187e-06  -1.696 0.095526 .
## MonthDec:RPM -4.151e-06  4.609e-06  -0.901 0.371672
## MonthFeb:RPM -3.943e-06  4.671e-06  -0.844 0.402265
## MonthJan:RPM -4.452e-06  4.524e-06  -0.984 0.329354
## MonthJul:RPM -9.566e-06  4.041e-06  -2.367 0.021395 *
## MonthJun:RPM -1.045e-05  3.813e-06  -2.741 0.008214 **
## MonthMar:RPM  1.602e-06  4.860e-06   0.330 0.742916
## MonthMay:RPM -4.509e-06  3.554e-06  -1.269 0.209777
## MonthNov:RPM -1.106e-05  4.525e-06  -2.445 0.017671 *
## MonthOct:RPM -1.261e-05  4.536e-06  -2.779 0.007403 **
## MonthSep:RPM -1.471e-05  4.385e-06  -3.354 0.001434 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 122.7 on 56 degrees of freedom
## Multiple R-squared:  0.7637, Adjusted R-squared:  0.6667
## F-statistic: 7.869 on 23 and 56 DF,  p-value: 1.702e-10
```

Forecast for RPM values

```
RPM_ts = ts(Tng$RPM, frequency = 12,start = c(2015,1))
acf(RPM_ts, lag = 80)
```



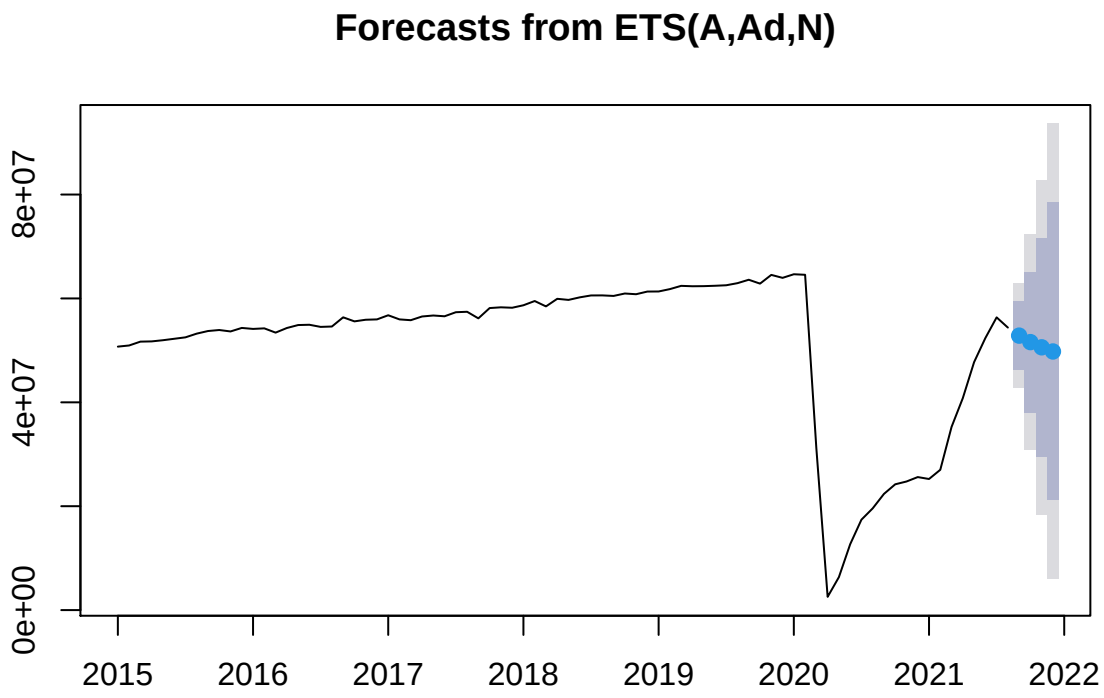

```
RPM_ets = ets(RPM_ts)
RPM_ets
```

```
## ETS(A,Ad,N)
##
## Call:
##  ets(y = RPM_ts)
##
##   Smoothing parameters:
##     alpha = 0.9977
##     beta  = 0.9977
##     phi   = 0.8
##
##   Initial states:
##     l = 50598263.196
##     b = 354870.1238
##
##   sigma:  5151280
##
##      AIC     AICc      BIC
## 2830.160 2831.311 2844.452
```

```
RPM_forecast = forecast(RPM_ets, h = 4)
RPM_forecast
```

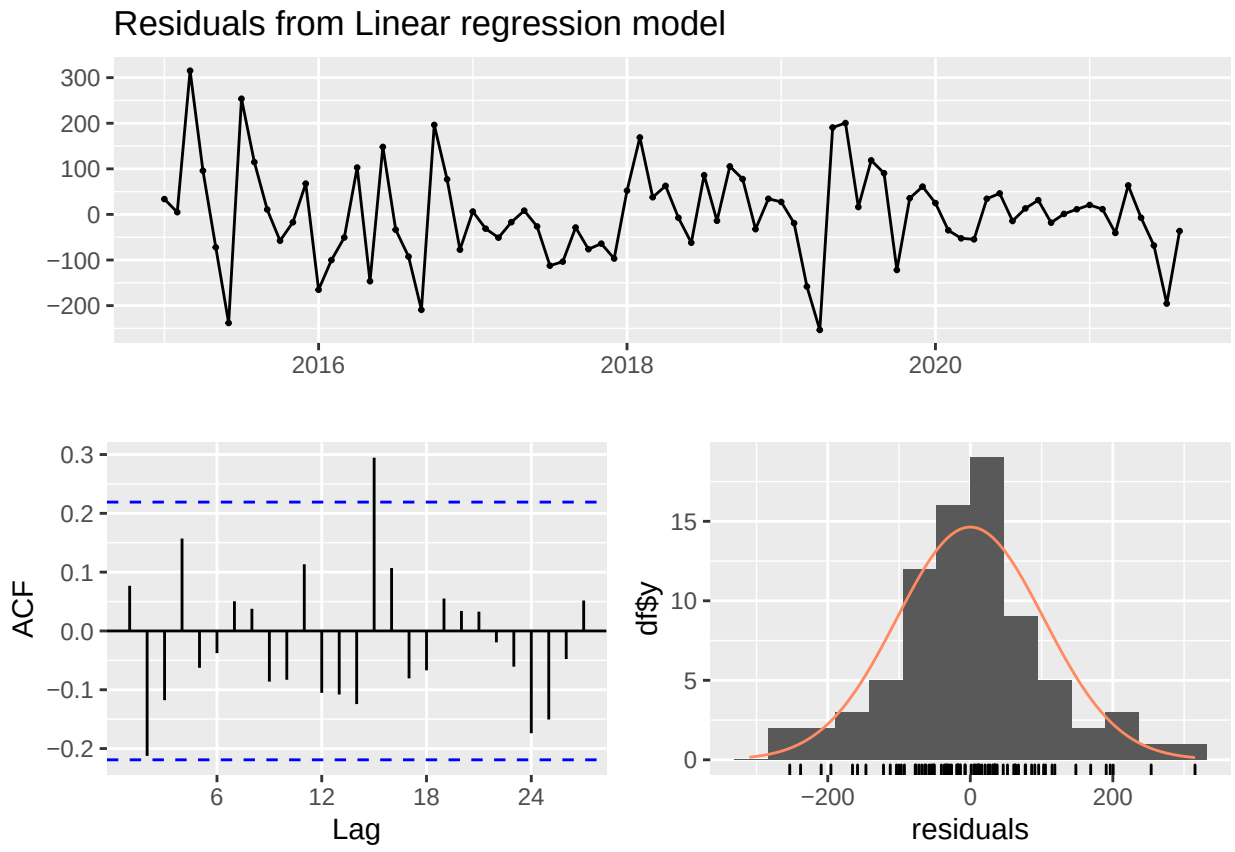
```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Sep 2021       52838196 46236565 59439827 42741872 62934520
## Oct 2021       51588074 38018603 65157545 30835359 72340789
## Nov 2021       50587976 29554821 71621132 18420541 82755412
## Dec 2021       49787898 21145026 78430771  5982405 93593392
```

```
plot(RPM_forecast)
```



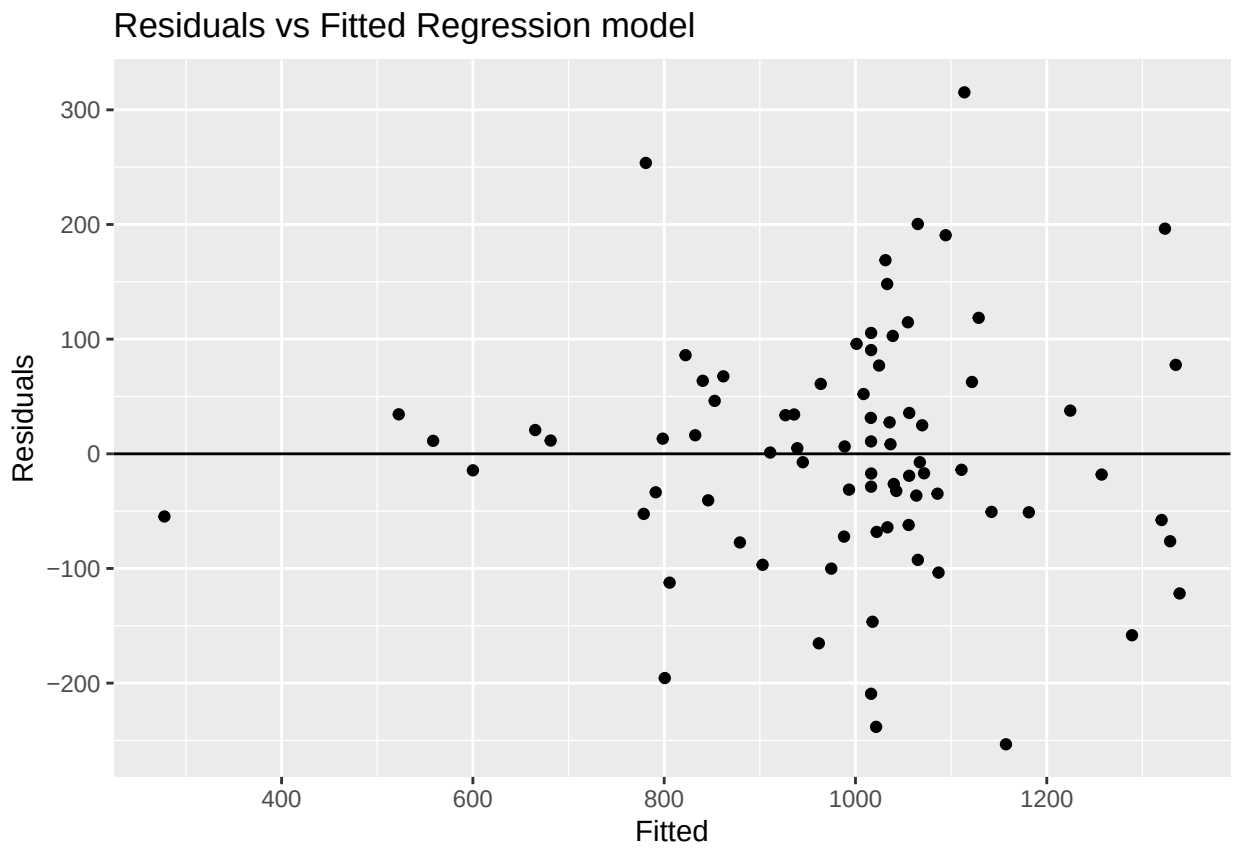
Checking residuals

```
checkresiduals(fit.step)
```

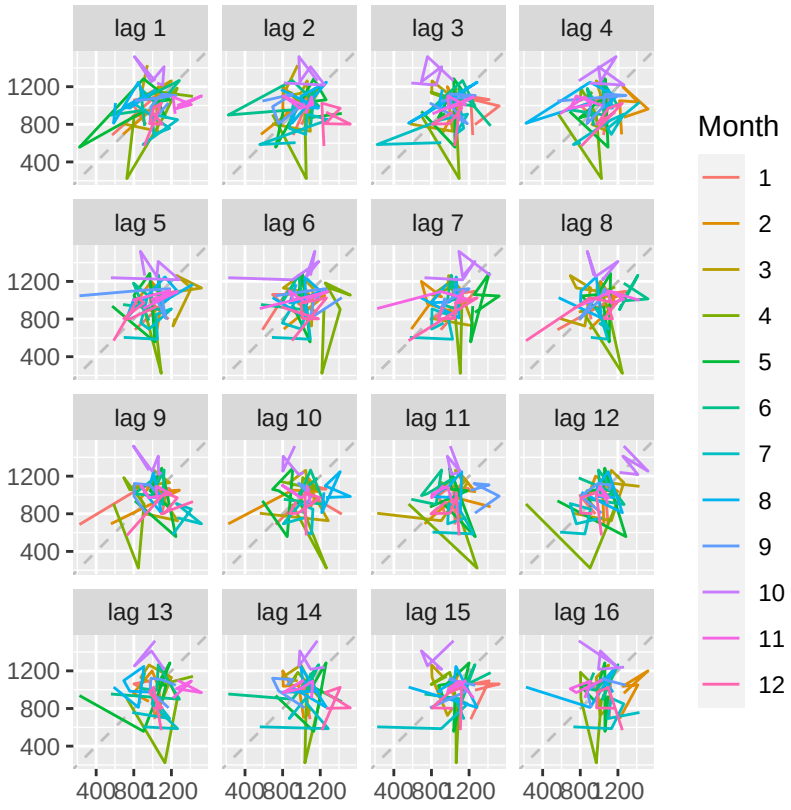



```
##
##  Breusch-Godfrey test for serial correlation of order up to 27
##
## data:  Residuals from Linear regression model
## LM test = 41.012, df = 27, p-value = 0.04108
```

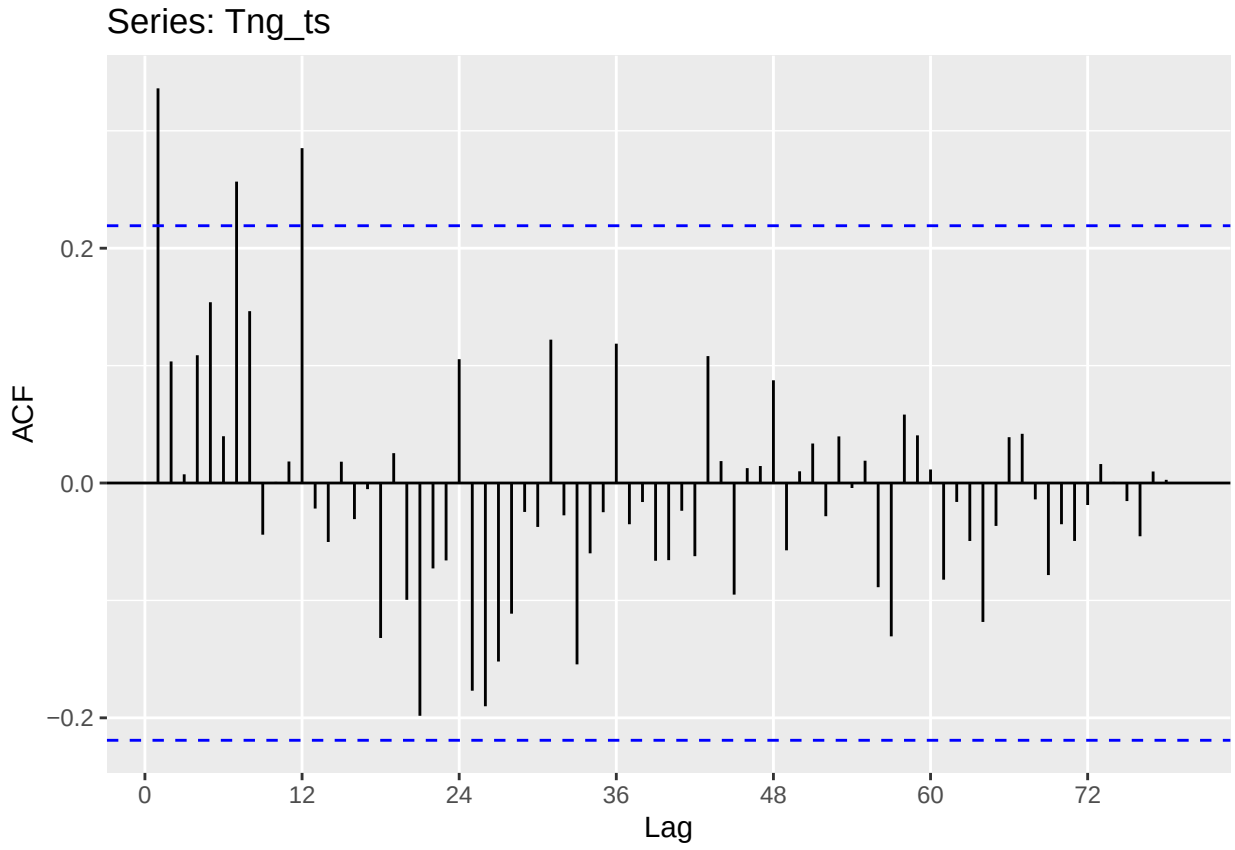
```
cbind(Fitted = fitted(fit.step),  Residuals=residuals(fit.step)) %>% as.data.frame() %>% ggplot(aes(x=F
```




```
gglagplot(Tng_ts)
```




```
ggAcf(Tng_ts, lag = 80)
```

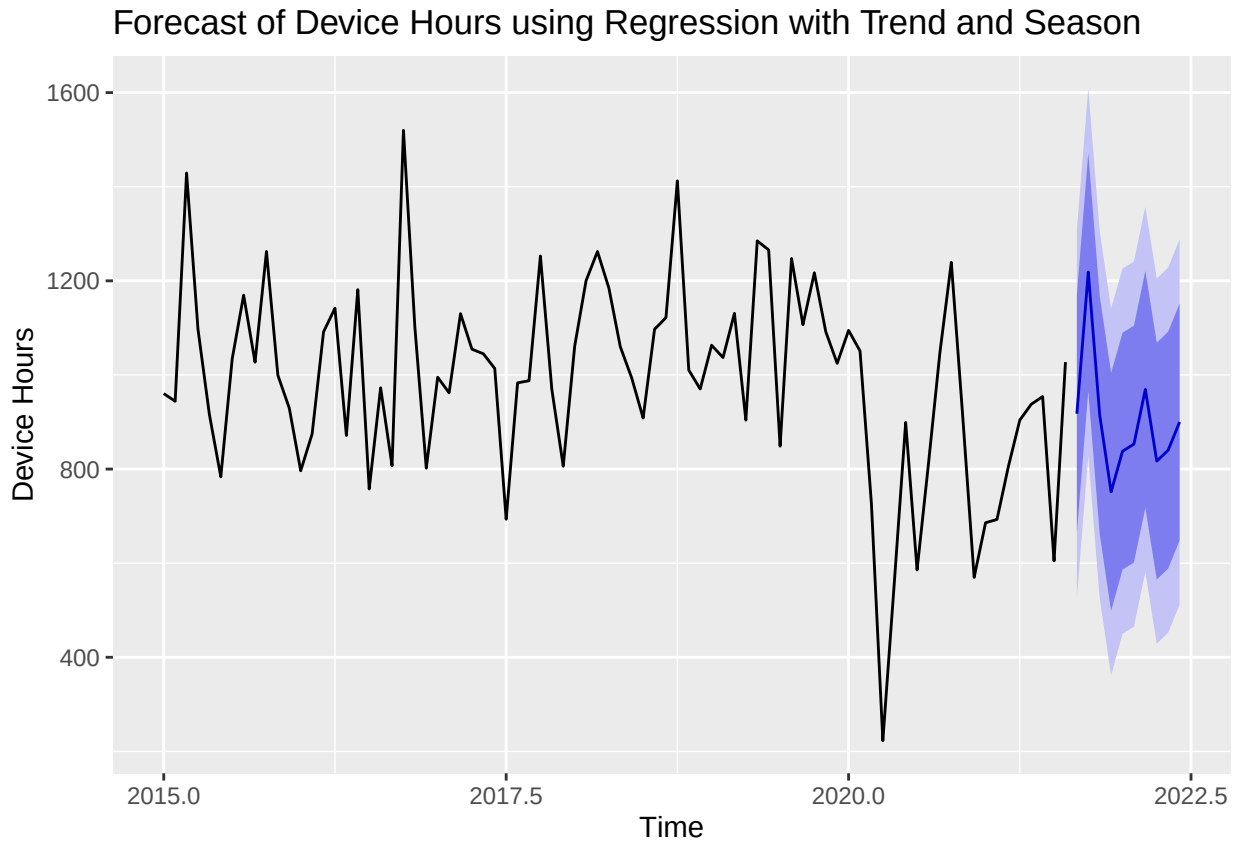



```
fit2.Tng = tslm(Tng_ts~trend + season)
summary(fit2.Tng)
```

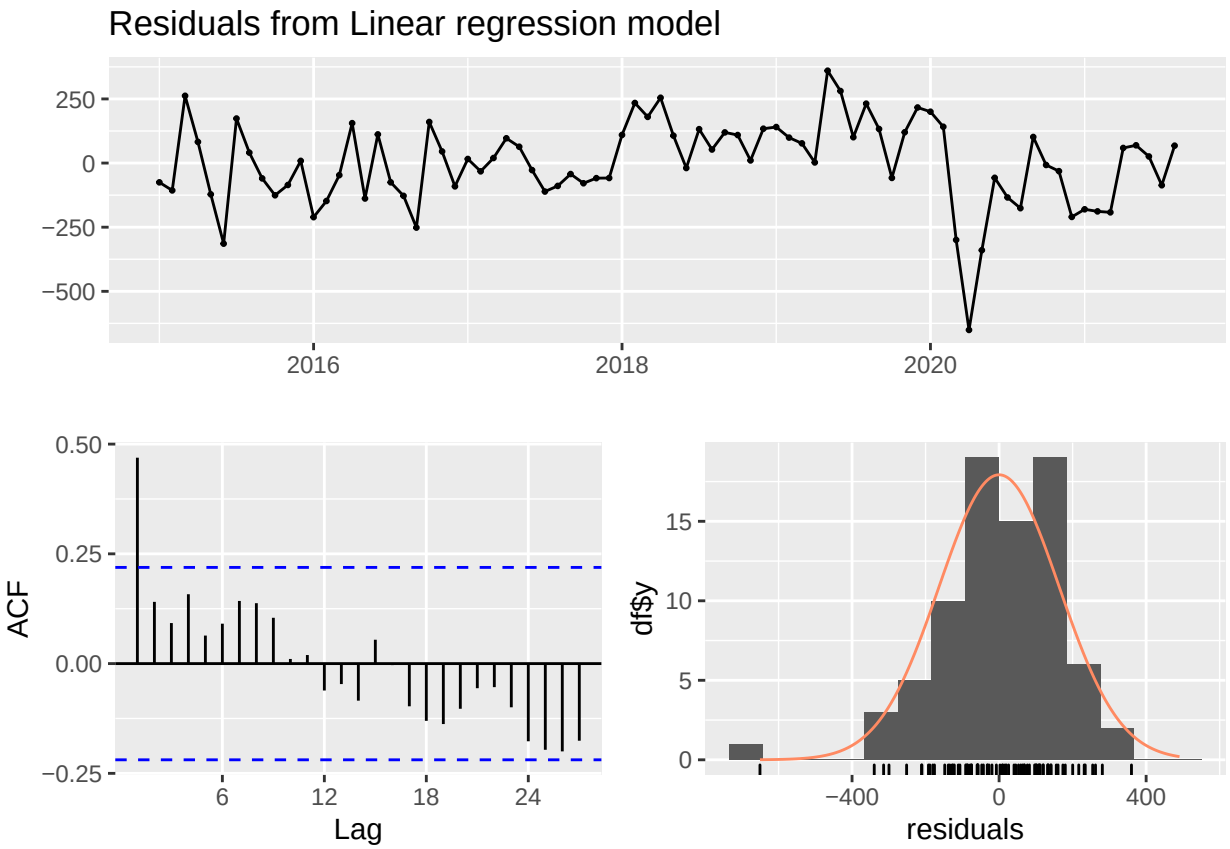
```
##
## Call:
## tslm(formula = Tng_ts ~ trend + season)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -650.56  -89.53    9.42  110.22  360.10
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 1037.9286    74.3502  13.960  < 2e-16 ***
## trend         -2.3527     0.8633  -2.725 0.008192 **
## season2       17.4284    94.9525   0.184 0.854922
## season3      136.0596    94.9643   1.433 0.156580
## season4      -13.9977    94.9839  -0.147 0.883283
## season5       11.6121    95.0114   0.122 0.903092
## season6       73.8119    95.0467   0.777 0.440136
## season7     -160.6169    95.0898  -1.689 0.095848 .
## season8      109.7001    95.1407   1.153 0.252995
## season9       70.1153    98.8407   0.709 0.480552
## season10     373.4680    98.8596   3.778 0.000339 ***
## season11      72.5723    98.8860   0.734 0.465571
```

```
## season12     -88.8017    98.9199  -0.898 0.372553
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 177.6 on 67 degrees of freedom
## Multiple R-squared:  0.4077, Adjusted R-squared:  0.3016
## F-statistic: 3.843 on 12 and 67 DF,  p-value: 0.0001816
```

```
fit2.forecast = forecast(fit2.Tng)
autoplot(fit2.forecast) + ggtitle("Forecast of Device Hours using Regression with Trend and Season") + x
```

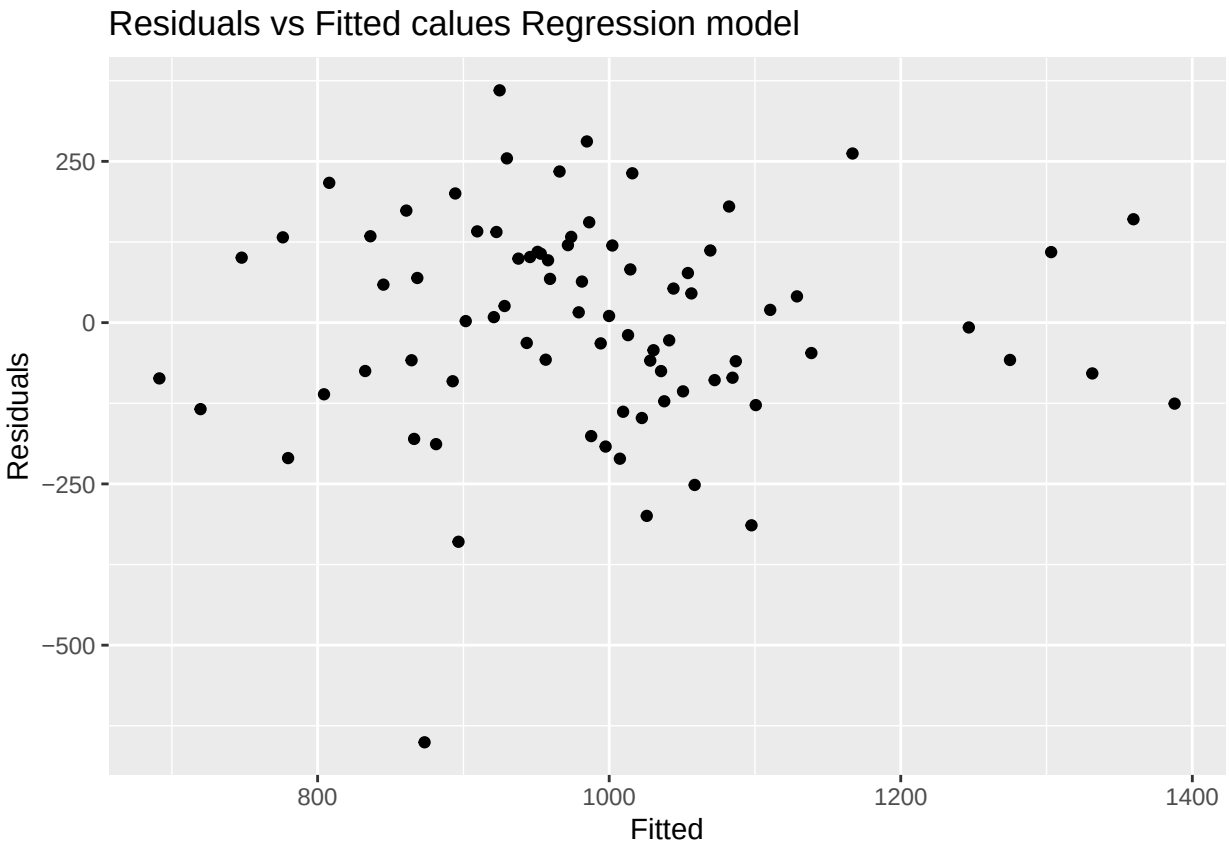



```
checkresiduals(fit2.Tng)
```




```
##
##  Breusch-Godfrey test for serial correlation of order up to 16
##
## data:  Residuals from Linear regression model
## LM test = 26.239, df = 16, p-value = 0.05076
```

```
cbind(Fitted = fitted(fit2.Tng), Residuals = residuals(fit2.Tng)) %>% as.data.frame() %>% ggplot(aes(x=
```


Residuals vs Fitted calues Regression model
250
0
−250
−500
Residuals
800
1000
1200
1400
Fitted