Trabalho7

June 27, 2025

[23]:
```
library(pacman)
p_load(dplyr,tidyr,splines,glarma)
```

[24]:
```
setwd('C:\\Users\\Marcelo\\OneDrive\\Área de Trabalho\\ts\\trabalho 2 -␣
↪TS\\Trabalho7')
getwd()
```

'C:/Users/Marcelo/OneDrive/Área de Trabalho/ts/trabalho 2 - TS/Trabalho7'

Função de Verossimilhança da Professora:

[25]:
```
Like <- function(Parametros, y, nb, np, nq, lamb, x, Ind) {


  ny <- length(y)

  # Separating parameters: beta, fi, theta
  if (nb > 0) {
    beta <- Parametros[1:nb]
  }

  ar_ma_start <- nb + 1

  if (np > 0 && nq == 0) {
    fi <- Parametros[ar_ma_start:(ar_ma_start + np - 1)]
  }

  if (nq > 0 && np == 0) {
    theta <- Parametros[ar_ma_start:(ar_ma_start + nq - 1)]
  }

  if (np > 0 && nq > 0) {
    fi <- Parametros[ar_ma_start:(ar_ma_start + np - 1)]
    theta <- Parametros[(ar_ma_start + np):(ar_ma_start + np + nq - 1)]
  }

  # Initialize variables
  z    <- rep(0, ny)
```

```r
w    <- rep(0, ny)
mi   <- rep(0, ny)
erro <- rep(0, ny)

# First observation: compute w[1]
if (nb == 0) {
  w[1] <- 0
} else if (nb == 1) {
  w[1] <- beta[1]
} else {
  w[1] <- beta[1] + as.numeric(x[1, 1:(nb - 1)] %*% beta[2:nb])
}

mi[1]   <- exp(w[1])
erro[1] <- (y[1] - mi[1]) / (mi[1]^lamb)
L       <- y[1] * w[1] - exp(w[1])

# Loop over t = 2 to ny
for (t in 2:ny) {

  # AR component
  if (np > 0) {
    for (k in 1:min(np, t - 1)) {
      z[t] <- z[t] + fi[k] * (z[t - k] + erro[t - k])
    }
  }

  # MA component
  if (nq > 0) {
    for (k in 1:min(nq, t - 1)) {
      z[t] <- z[t] + theta[k] * erro[t - k]
    }
  }

  # Compute w[t] based on z[t] and x[t,]
  if (nb == 0) {
    w[t] <- z[t]
  } else if (nb == 1) {
    w[t] <- beta[1] + z[t]
  } else {
    w[t] <- beta[1] + as.numeric(x[t, 1:(nb - 1)] %*% beta[2:nb]) + z[t]
  }

  mi[t]   <- exp(w[t])
  erro[t] <- (y[t] - mi[t]) / (mi[t]^lamb)
  L       <- L + y[t] * w[t] - exp(w[t])
}
```

```
  L <- -L  # negative log-likelihood

  valores <- cbind(erro, z, mi)

  if (Ind == 0) return(L)
  if (Ind == 1) return(valores)
}
```

Função que adiciona faz a estimação, calcula o AIC dado o numero de bases para cada covariável não linear:

[26]:
```
MLE_com_splines <- function(y, z_list, k_list,
                            other_covariates = NULL,
                            np = 0, nq = 0, lamb = 0.5,
                            Ind = 0) {

  nz <- length(z_list)

  # Construindo as bases splines com seus respectivos ks.
  spline_list <- list()
  spline_sizes <- integer(nz)

  for (i in seq_along(z_list)) {
    k_i <- k_list[[i]]
    spline_i <- ns(z_list[[i]], df = k_i) #bases splines para a variável não␣
↪linear numero i
    spline_list[[i]] <- spline_i #lista com as bases
    spline_sizes[i] <- ncol(spline_i) #numero de bases a variavel não linear i
  }

  # juntando as bases splines usando cbind:
  names(spline_list) <- names(z_list)
  spline_basis <- do.call(cbind, spline_list)
  n_spline <- sum(spline_sizes)

  # Juntando com as outras covariáveis:
  if (!is.null(other_covariates)) {
    x <- cbind(spline_basis, other_covariates)
    n_other <- ncol(other_covariates)
  } else {
    x <- spline_basis
    n_other <- 0
  }

  nb <- 1 + n_spline + n_other  # intercepto + splines + numero betas das outras␣
↪cov
```

```
n_params <- nb + np + nq
start_vals <- rep(0, n_params)

# ajustando o modelo dado um numero fixo de bases para cada covariável não
↪linear:
opt <- optim(par = start_vals,
             fn = Like,
             y = y,
             nb = nb,
             np = np,
             nq = nq,
             lamb = lamb,
             x = x,
             Ind = Ind,
             method = "BFGS",
             hessian = FALSE)

logLik <- -opt$value
AIC <- 2 * n_params - 2 * logLik

best_coef <- opt$par
beta0 <- best_coef[1]
beta_spline_all <- best_coef[2:(1 + n_spline)]

# separando os coeficientes das bases splines para cada variável não linear:
beta_spline_list <- list()
idx <- 1
for (i in seq_along(z_list)) {
  varname <- names(z_list)[i]
  len <- spline_sizes[i]
  beta_spline_list[[varname]] <- beta_spline_all[idx:(idx + len - 1)]
  idx <- idx + len
}

# separando os outros coeficientes:
beta_other <- if (n_other > 0)
    {best_coef[(2 + n_spline):(1 + n_spline + n_other)]}
              else {numeric(0)}

fi   <- if (np > 0)
    {best_coef[(nb + 1):(nb + np)]}
              else {numeric(0)}

theta <- if (nq > 0)
    {best_coef[(nb + np + 1):(nb + np + nq)]}
     else {numeric(0)}
```

```r
  fit <- list(
    AIC = AIC,
    logLik = logLik,
    beta0 = beta0,
    beta_spline = beta_spline_list,
    beta_other = beta_other,
    fi = fi,
    theta = theta,
    k_list = k_list
  )

  return(fit)
}
```

[27]:

```r
select_best_k_multi <- function(y, z_list, k_ranges,
                                other_covariates = NULL,
                                np = 0, nq = 0, lamb = 0.5,
                                Ind = 0) {

  # Gerando um grid com os possíveis numeros de bases para cada variável spline:

  k_grid <- expand.grid(k_ranges)

  best_AIC <- Inf
  best_fit <- NULL
  best_k_list <- NULL

 #calculando o AIC para cada combinação de número de bases:
  for (i in seq_len(nrow(k_grid)))
  {
    current_k <- as.list(k_grid[i, ])

    result <- tryCatch({
                          MLE_com_splines(
                            y = y,
                            z_list = z_list,
                            k_list = current_k,
                            other_covariates = other_covariates,
                            np = np,
                            nq = nq,
                            lamb = lamb,
                            Ind = Ind
                          )
                        },
                       error = function(e) {return(NULL)}
                      )
```

```
    if (!is.null(result) && result$AIC < best_AIC) {

      best_AIC <- result$AIC
      best_fit <- result
      best_k_list <- current_k
    }
  }

  best_fit$k_list <- best_k_list
  return(best_fit)
}
```

Pegando o dataset de Doença respiratórias:

[28]:
```
df <- read.csv("DR.csv",header = TRUE,sep=';')
```

[29]:
```
summary(df)
```

```
     Data            Atendimentos     tempmed               O3
 Length:72          Min.   : 1.0   Length:72          Length:72
 Class :character   1st Qu.:12.0   Class :character   Class :character
 Mode  :character   Median :21.5   Mode  :character   Mode  :character
                    Mean   :24.1
                    3rd Qu.:33.0
                    Max.   :91.0
      CO                NO2                SO2
 Length:72          Length:72          Length:72
 Class :character   Class :character   Class :character
 Mode  :character   Mode  :character   Mode  :character
```

[30]:
```
df<- df %>% select(Atendimentos,tempmed,O3,CO,NO2,SO2)
```

Limpando os dados:

[31]:
```
df[] <- lapply(df, function(x) {
  if (is.character(x)) as.numeric(gsub(",", ".", x)) else x
})
```

[32]:
```
summary(df)
```

```
  Atendimentos      tempmed            O3              CO
 Min.   : 1.0   Min.   :18.85   Min.   :16.76   Min.   : 295.2
 1st Qu.:12.0   1st Qu.:22.61   1st Qu.:26.34   1st Qu.: 645.7
 Median :21.5   Median :23.97   Median :32.22   Median : 829.8
 Mean   :24.1   Mean   :24.17   Mean   :32.72   Mean   : 826.8
 3rd Qu.:33.0   3rd Qu.:26.02   3rd Qu.:38.44   3rd Qu.:1018.4
```

```
 Max.   :91.0   Max.   :29.14   Max.   :48.15   Max.   :1616.3
      NO2              SO2
 Min.   :11.19   Min.   : 5.959
 1st Qu.:19.33   1st Qu.: 9.361
 Median :24.45   Median :11.140
 Mean   :24.42   Mean   :11.809
 3rd Qu.:28.70   3rd Qu.:13.695
 Max.   :38.72   Max.   :20.420
```

[33]:
```
df<- df %>% drop_na()
```

Montando o X:

[34]:
```
X <- as.matrix(df[ , setdiff(names(df), "Atendimentos")])
```

Ajustando o modelo sem os splines:

[35]:
```
fit =glarma(df$Atendimentos, X=X , phiLags = c(1) ,thetaLags = NULL, type =␣
 ↪"Poi")
summary(fit)
```

```
Call: glarma(y = df$Atendimentos, X = X, type = "Poi", phiLags = c(1),
    thetaLags = NULL)

Pearson Residuals:
    Min       1Q   Median       3Q      Max
-5.1470  -1.5949  -0.2822   1.8875  11.4303

GLARMA Coefficients:
      Estimate Std.Error z-ratio Pr(>|z|)
phi_1 0.064316  0.007945   8.095 6.66e-16 ***

Linear Model Coefficients:
          Estimate  Std.Error z-ratio Pr(>|z|)
tempmed  0.0626788  0.0080746   7.763 8.44e-15 ***
O3       0.0417608  0.0038306  10.902  < 2e-16 ***
CO       0.0018250  0.0001737  10.508  < 2e-16 ***
NO2     -0.0078196  0.0055289  -1.414    0.157
SO2     -0.0994414  0.0113291  -8.778  < 2e-16 ***

    Null deviance: 795.53  on 71  degrees of freedom
Residual deviance: 612.48  on 66  degrees of freedom
AIC: 943.4291

Number of Fisher Scoring iterations: 30

LRT and Wald Test:
Alternative hypothesis: model is a GLARMA process
```

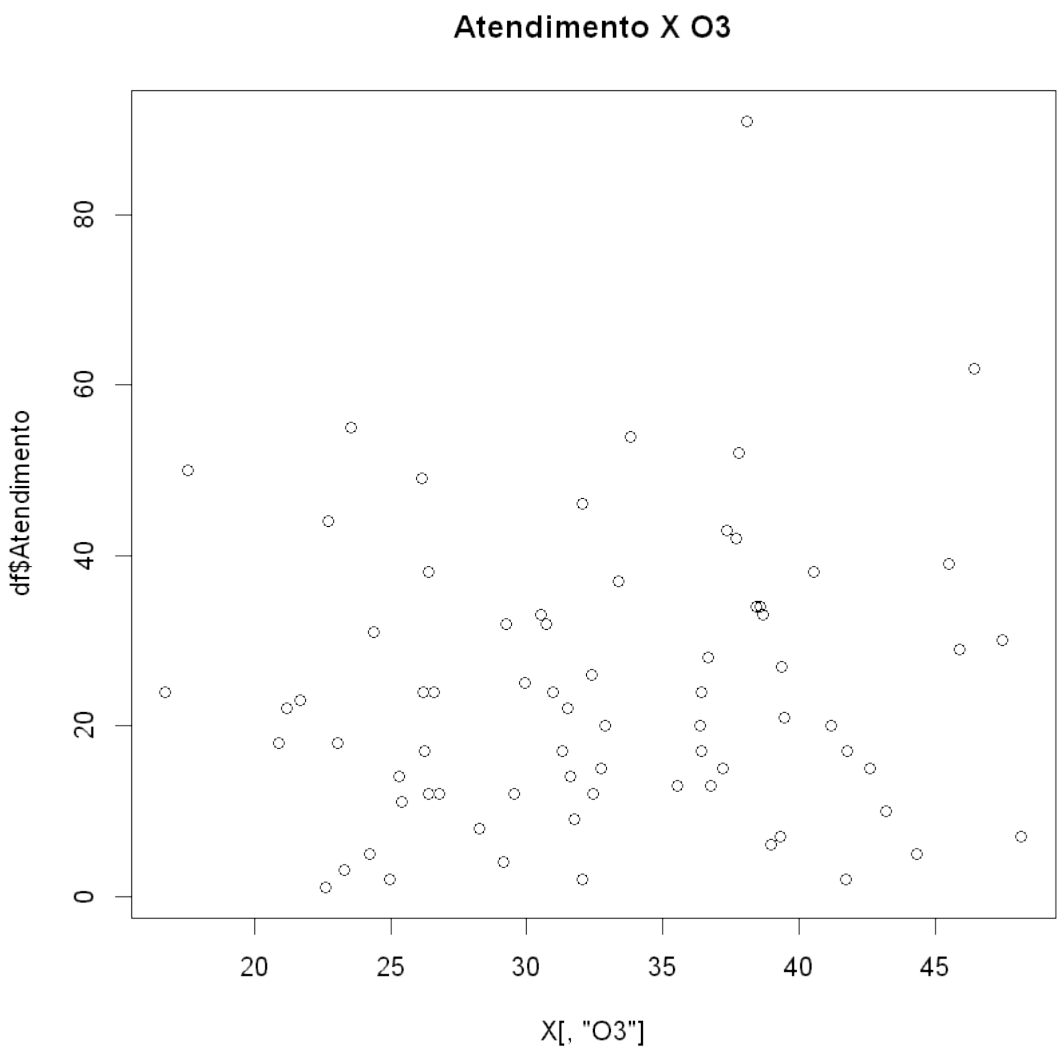
```
Null hypothesis: model is a GLM with the same regression structure
          Statistic  p-value
LR Test       75.71  < 2e-16 ***
Wald Test     65.53 5.55e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

[36]:
```
fit =glarma(df$Atendimentos, X=X[,c('tempmed','O3','CO','SO2')] , phiLags =␣
 ↪c(1,2) ,thetaLags = NULL, type = "Poi")
summary(fit)
```

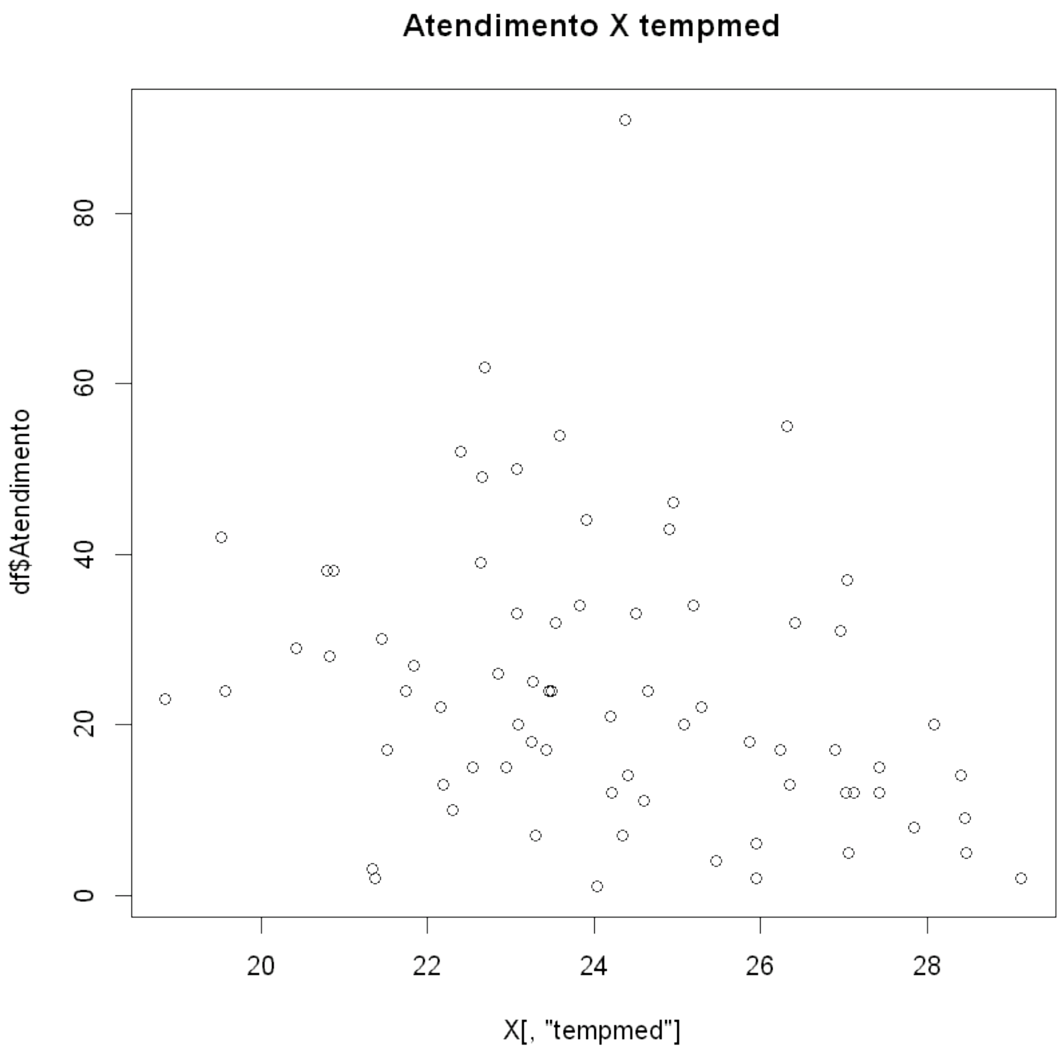
```
Call: glarma(y = df$Atendimentos, X = X[, c("tempmed", "O3", "CO",
    "SO2")], type = "Poi", phiLags = c(1, 2), thetaLags = NULL)

Pearson Residuals:
    Min       1Q   Median       3Q      Max
-5.2529  -1.7941  -0.1555   1.4626   8.5222

GLARMA Coefficients:
      Estimate Std.Error z-ratio Pr(>|z|)
phi_1 0.082932  0.008198  10.116  < 2e-16 ***
phi_2 0.046149  0.008895   5.188 2.13e-07 ***

Linear Model Coefficients:
          Estimate  Std.Error z-ratio Pr(>|z|)
tempmed  0.0639349  0.0083392   7.667 1.75e-14 ***
O3       0.0364563  0.0032981  11.054  < 2e-16 ***
CO       0.0013487  0.0001142  11.814  < 2e-16 ***
SO2     -0.0720963  0.0118371  -6.091 1.12e-09 ***

    Null deviance: 795.53  on 71  degrees of freedom
Residual deviance: 578.17  on 66  degrees of freedom
AIC: 917.5981

Number of Fisher Scoring iterations: 30

LRT and Wald Test:
Alternative hypothesis: model is a GLARMA process
Null hypothesis: model is a GLM with the same regression structure
          Statistic p-value
LR Test       106.0  <2e-16 ***
Wald Test     112.5  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

A partir do AR(2) os coeficientes do phi não são significativos em todos os níveis de confiança.

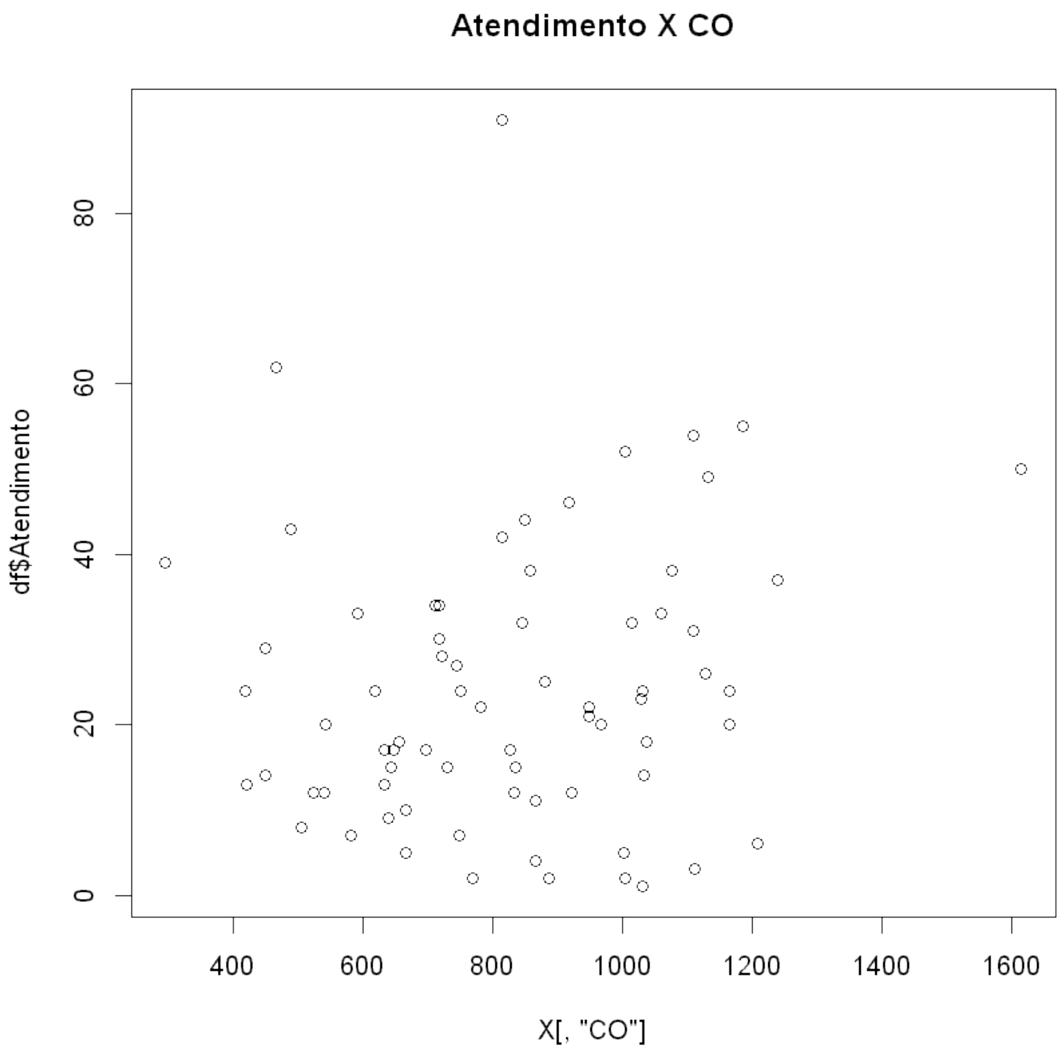
[37]:
```
plot(X[, "O3"], df$Atendimento, main = "Atendimento X O3")
```



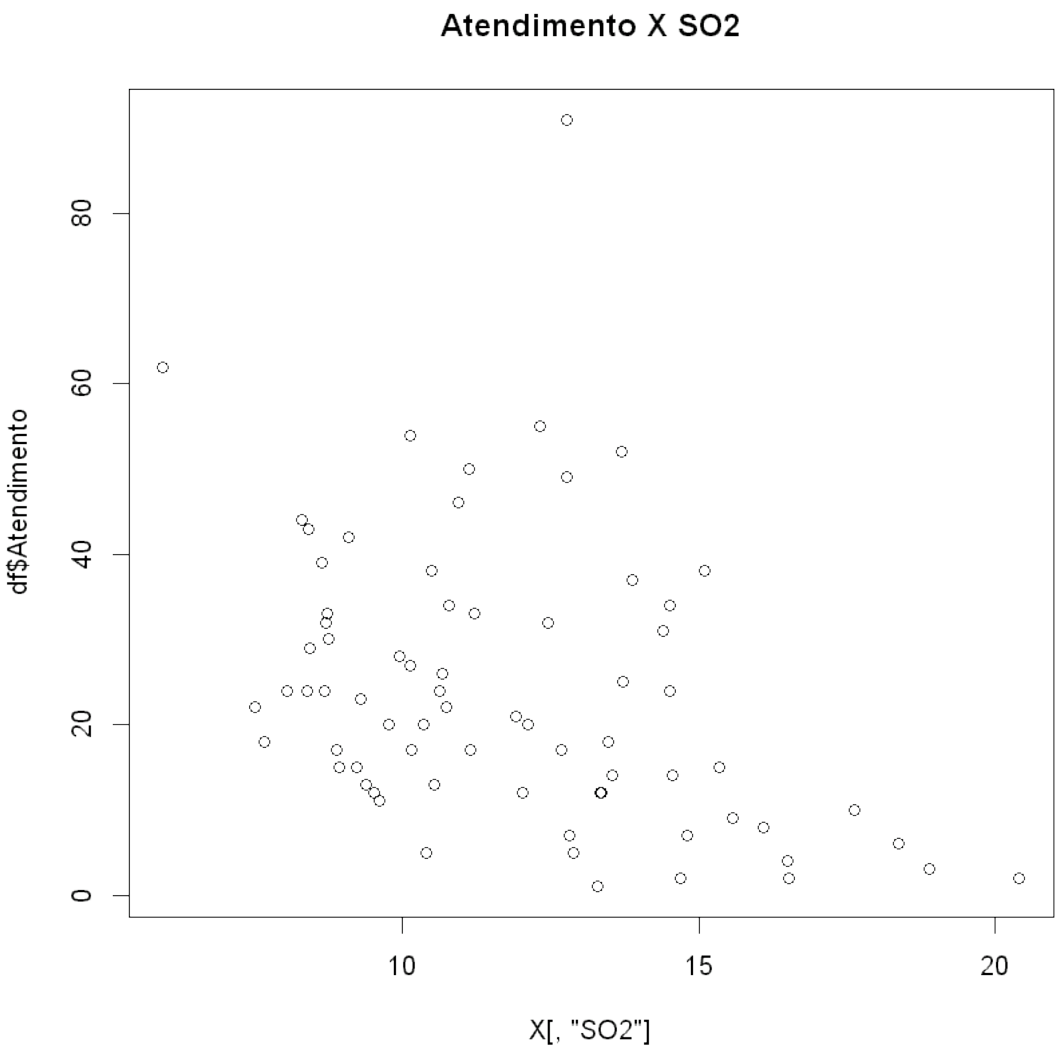
[38]:
```
plot(X[, "tempmed"], df$Atendimento, main = "Atendimento X tempmed")
```



[39]:
```
plot(X[, "CO"], df$Atendimento, main = "Atendimento X CO")
```



[40]:
```
plot(X[, "SO2"], df$Atendimento, main = "Atendimento X SO2")
```



O3 aparentemente tem relação não linear com o número de atendimentos

Rodando nossa regressão com os splines:

[41]:
```
other_covs <- X[,c('tempmed','CO','SO2')]
```

[42]:
```
resposta<-select_best_k_multi(y=df$Atendimentos,z=list(O3=df$O3,tempmed=df$tempmed),other_covar
↪= other_covs,
                                k_ranges=list(O3=1:8,temp_med=1:8),np=3,nq=0,lamb =0.
↪5,Ind=0)
```

[43]:
```
resposta
```

$AIC -7840.30738737551

$logLik 3942.15369368775

$beta0 2.76306610689278

$beta_spline **$O3** 1. 0.351727607570428 2. 0.748339770830553 3. 0.0514625420616618 4. 1.07794204788271 5. -0.521010265442694 6. 0.572686123411616 7. 0.636101002121954

$tempmed 1. -0.10411575379499 2. -0.342784661481924 3. -0.0206866784576695 4. -0.127113092415123 5. -0.622252363904484 6. 0.0563834096290639 7. -1.64067137163042 8. -1.7303685099724

$beta_other 1. 0.0284734533890816 2. 0.000740302083696139 3. -0.0866522606064693

$fi 1. 0.0433467203032375 2. 0.00227101251663183 3. -0.0660772354515024

$theta

$k_list **$O3** 7

$temp_med 8

```
[ ]:
```