MSwM package

February 22, 2017

The package for implementing Autoregressive Markov switching model

```
msmFit(object, k, sw, p, data, family, control)
```

- `object`: formula of class "lm"
  - Dependent variable: $TotCpu$
  - Independent variables: $RrcConnectionSetupComplete$, $X2HandoverRequest$, $Paging$, ... (a subset of components in $EventsPerSec$)
- `k`: Number of states (regime)
- `sw`: Swiching coefficient
- `p`: Order of AR model
- `control`: A list of control parameters

```
library(MSwM)
g2_L16B_min <- read.csv("C:/Users/EARAEAM/Documents/Thesis/Data/g2_L16B_min.csv")
colnames(g2_L16B_min)[14] <- "TotCpu" # need to rename the variable by removing %

train_num <- floor(nrow(g2_L16B_min) * 0.8) # divide train (80) test (20)
train_g2_L16B_min <- g2_L16B_min[1:train_num,]
test_g2_L16B_min <- g2_L16B_min[-c(1:train_num),]

predictor <- c("RrcConnectionSetupComplete","Paging","X2HandoverRequest")
fmla <- as.formula(paste("TotCpu ~ ", paste(predictor, collapse= "+")))
mod <- lm(fmla, data=train_g2_L16B_min)

set.seed(12)
# fit model with three states and first order autoregressive
model_mswm <- msmFit(mod, k=3, p=1, sw=rep(TRUE,length(mod$coefficients)+1+1),
                     control=list(trace=FALSE, maxiter=500, parallel=FALSE))
```

Output

- `std`: standard deviation for each state
- `Coef`: coefficients of the model
- `seCoef`: statndard errors of the coefficients
- `transMat`: transition probabilities matrix of the states
- `Fit`: values obtained for fitting model with EM algorithm
  - `CondMean`: conditional mean for each state
  - `error`: conditional residuals of the model for each state
  - `Likel`: likelihood for each state
  - `margLik`: marginal likelihood for each observation
  - `filtProb`: filtered probabilities for each state
  - `smoProb`: smoothed probabilities for each state
  - `smoTransMat`: smoothed probabilities for each observation between all the states
  - `logLikel`: global loglikelihood of the model

Parameter estimation

```
summary(model_mswm)
```

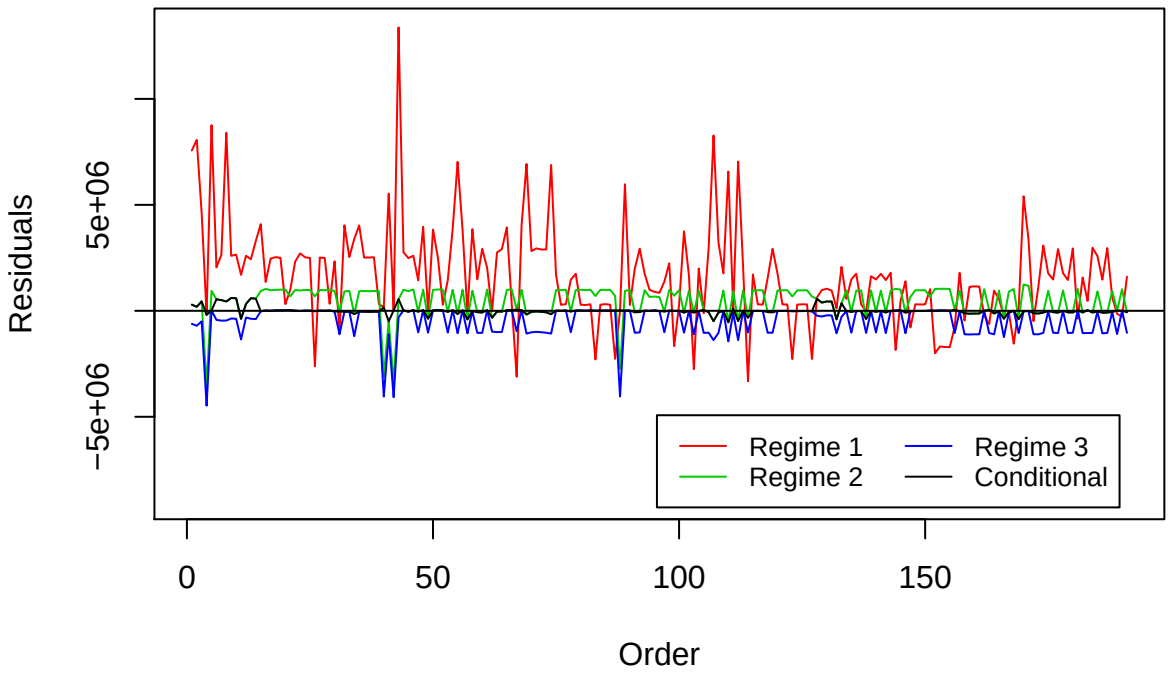
```
## Markov Switching Model
##
## Call: msmFit(object = mod, k = 3, sw = rep(TRUE, length(mod$coefficients) +
##     1 + 1), p = 1, control = list(trace = FALSE, maxiter = 500,
##     parallel = FALSE))
##
##        AIC      BIC    logLik
##   5115.775 5243.343 -2542.887
##
## Coefficients:
##
## Regime 1
## ---------
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)(S)                -1.0417e+07         NA      NA       NA
## RrcConnectionSetupComplete(S)  3.3590e+04         NA      NA       NA
## Paging(S)                      5.1168e+03         NA      NA       NA
## X2HandoverRequest(S)          -5.6324e+04         NA      NA       NA
## TotCpu_1(S)                    1.3996e+00         NA      NA       NA
##
## Residual standard error: 106878.9
## Multiple R-squared: 0.9963
##
## Standardized Residuals:
##           Min            Q1           Med            Q3           Max
## -1.944992e+05  0.000000e+00  2.361393e-54  2.822513e-07  1.576835e+05
##
## Regime 2
## ---------
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)(S)                 5.1505e+06         NA      NA       NA
## RrcConnectionSetupComplete(S) -1.2211e+03         NA      NA       NA
## Paging(S)                      1.5502e+02         NA      NA       NA
## X2HandoverRequest(S)          -6.3931e+03         NA      NA       NA
## TotCpu_1(S)                   -1.3800e-02         NA      NA       NA
##
## Residual standard error: 281075.7
## Multiple R-squared: 0.2523
##
## Standardized Residuals:
##        Min         Q1        Med         Q3        Max
## -543775.80  -53698.06   10183.82   25633.74  604591.80
##
## Regime 3
## ---------
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)(S)                 5.9893e+06         NA      NA       NA
## RrcConnectionSetupComplete(S) -8.1172e+02         NA      NA       NA
## Paging(S)                     -2.2768e+01         NA      NA       NA
## X2HandoverRequest(S)          -2.5645e+02         NA      NA       NA
```

```
## TotCpu_1(S)                   -2.5000e-03         NA       NA       NA
##
## Residual standard error: 20730.75
## Multiple R-squared: 0.7979
##
## Standardized Residuals:
##        Min         Q1        Med         Q3        Max
## -59319.323  -3138.972      0.000   5097.785  35752.684
##
## Transition probabilities:
##           Regime 1   Regime 2  Regime 3
## Regime 1 0.0000000 0.06203846 0.0476257
## Regime 2 0.4895592 0.47779066 0.3507630
## Regime 3 0.5104408 0.46017087 0.6016113
```

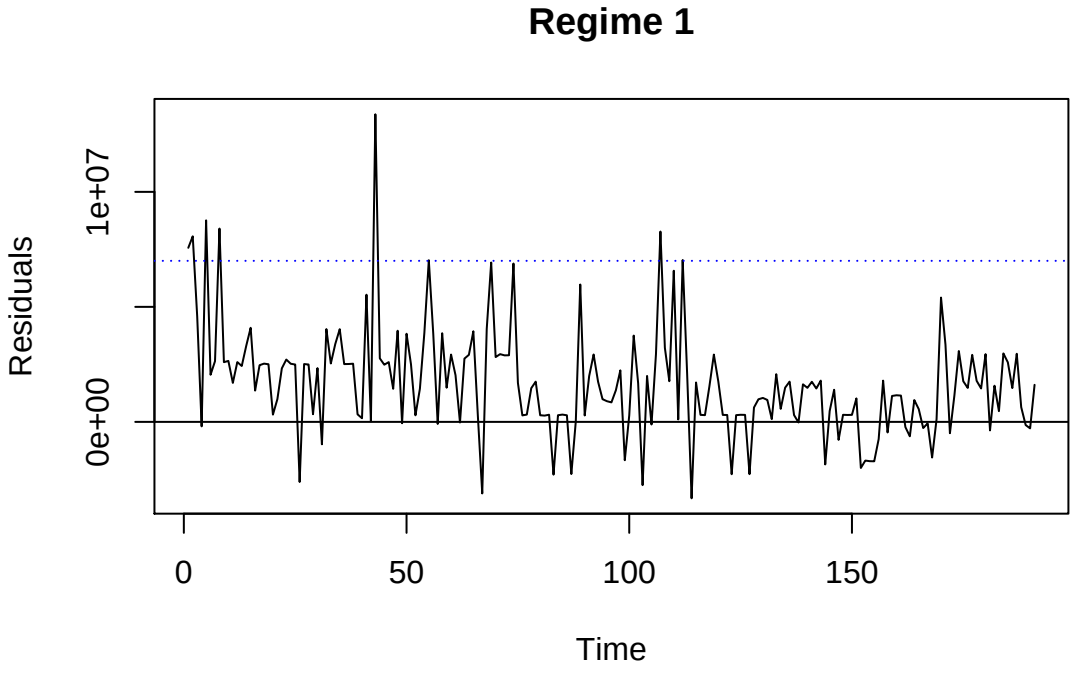
Graphic

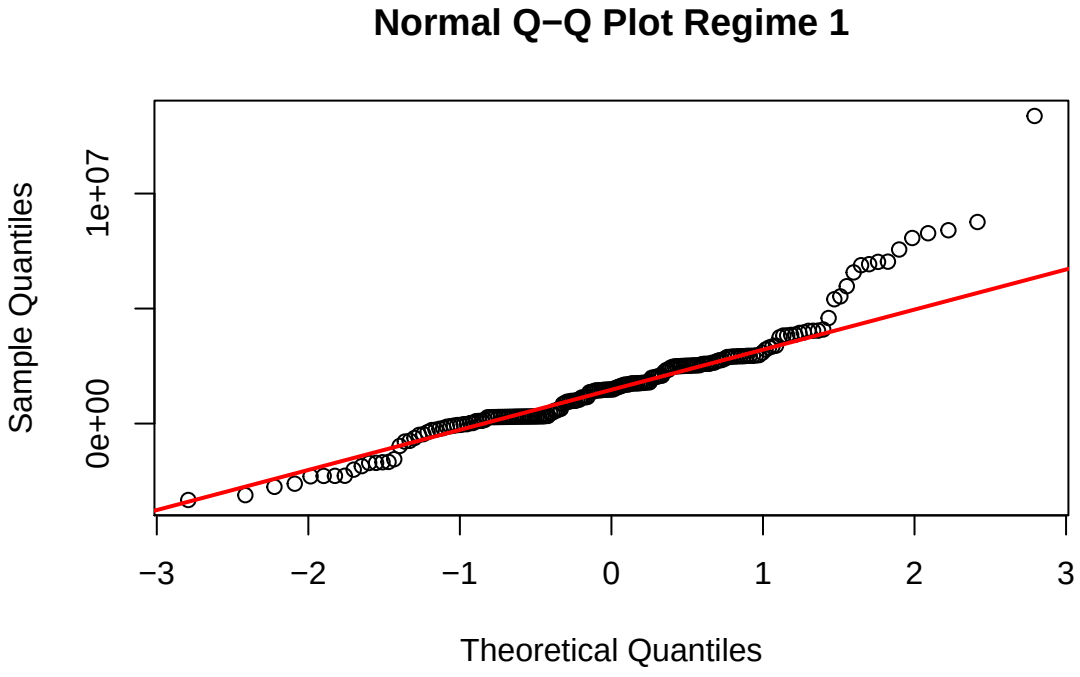
Residuals plot for each regime with the conditional residuals

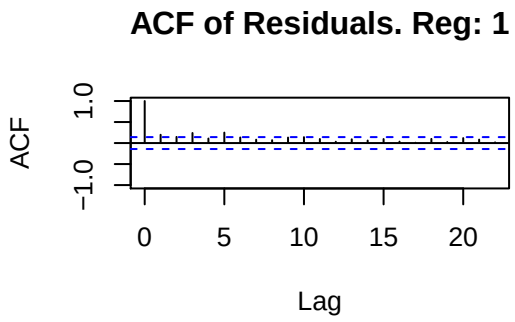
```
plot(model_mswm)
```

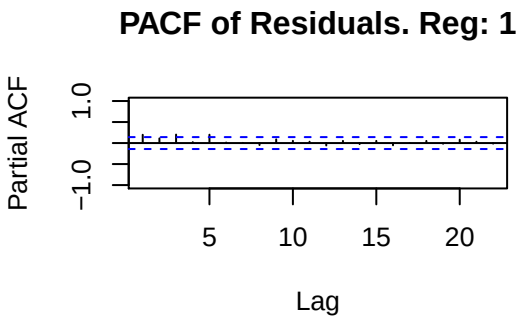


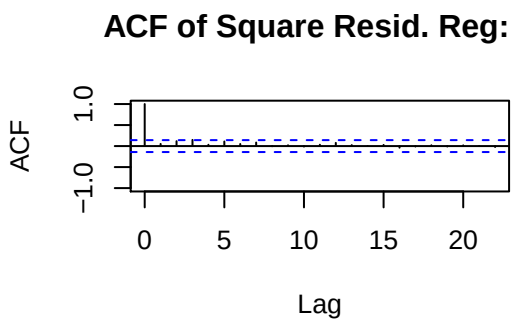
plotDiag: Plot for the residual analysis

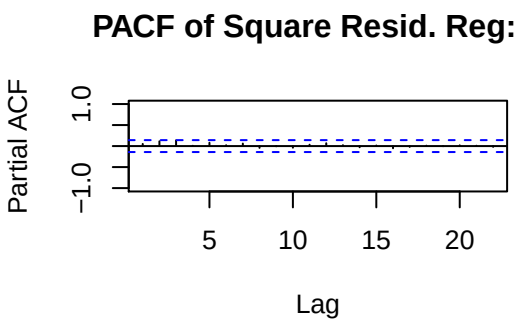


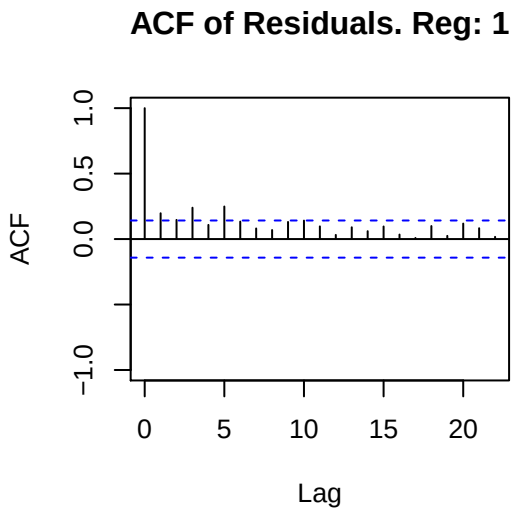


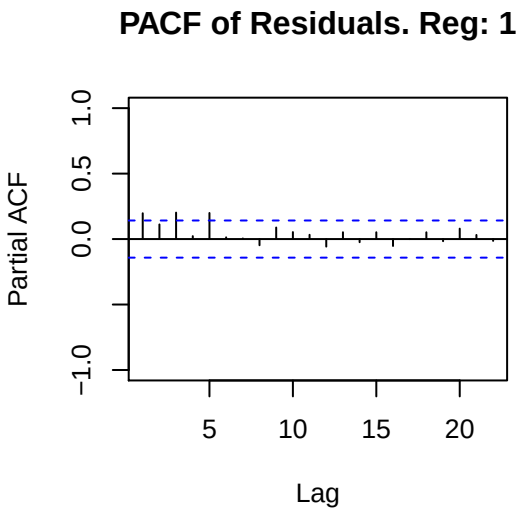

ACF of Residuals. Reg: 1
ACF
1.0
−1.0
0
5
10
15
20
Lag

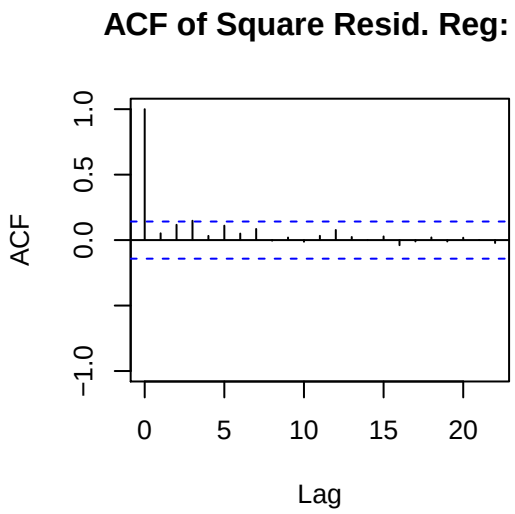

PACF of Residuals. Reg: 1
Partial ACF
1.0
−1.0
5
10
15
20
Lag

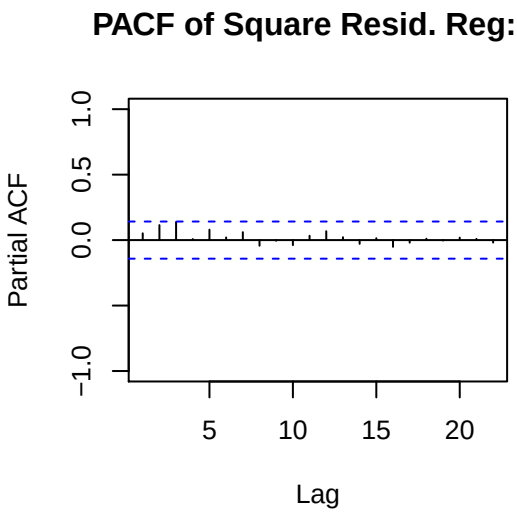

ACF of Square Resid. Reg: 1
ACF
1.0
−1.0
0
5
10
15
20
Lag


PACF of Square Resid. Reg: 1
Partial ACF
1.0
−1.0
5
10
15
20
Lag

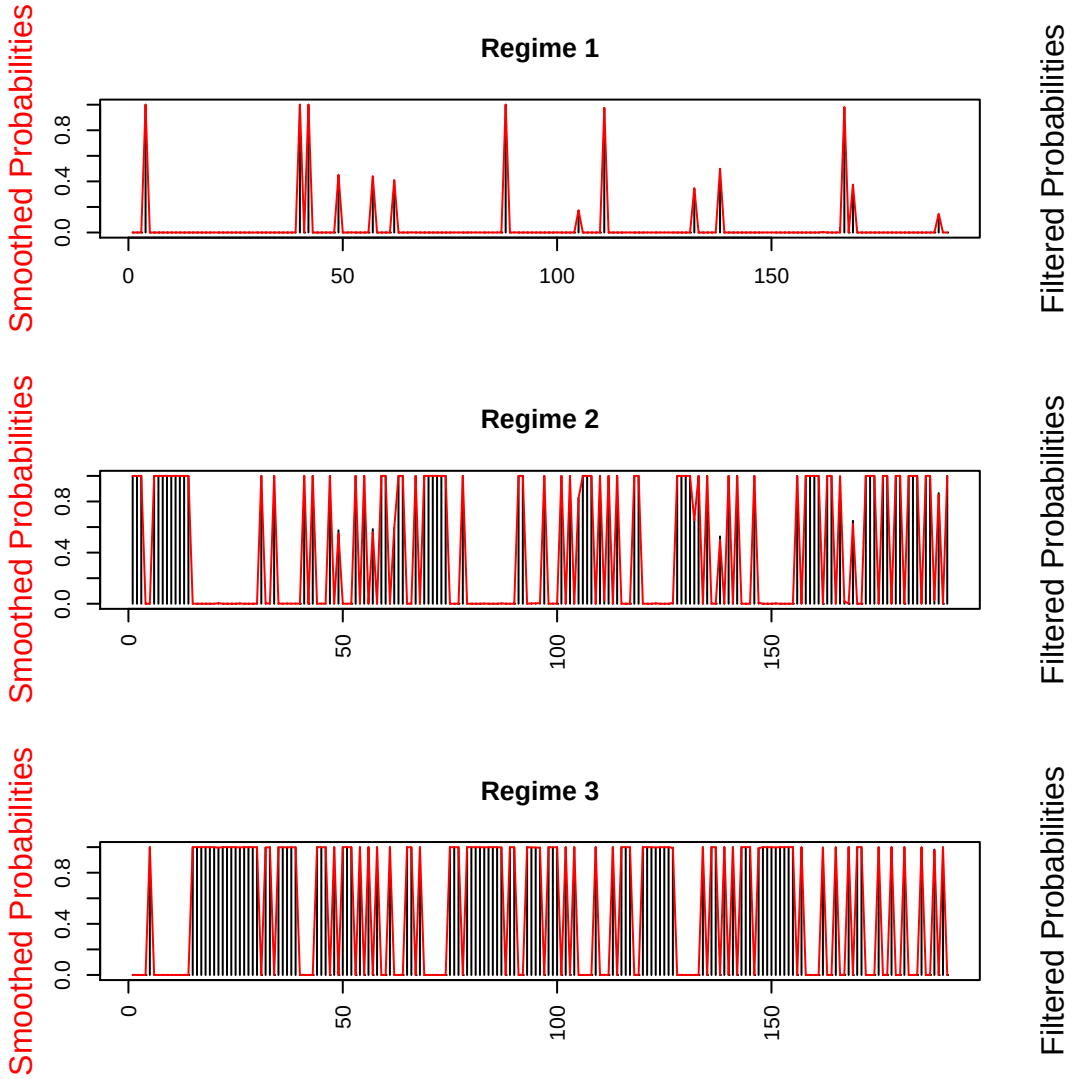

ACF of Residuals. Reg: 1
ACF
1.0
0.5
0.0
−1.0
0
5
10
15
20
Lag

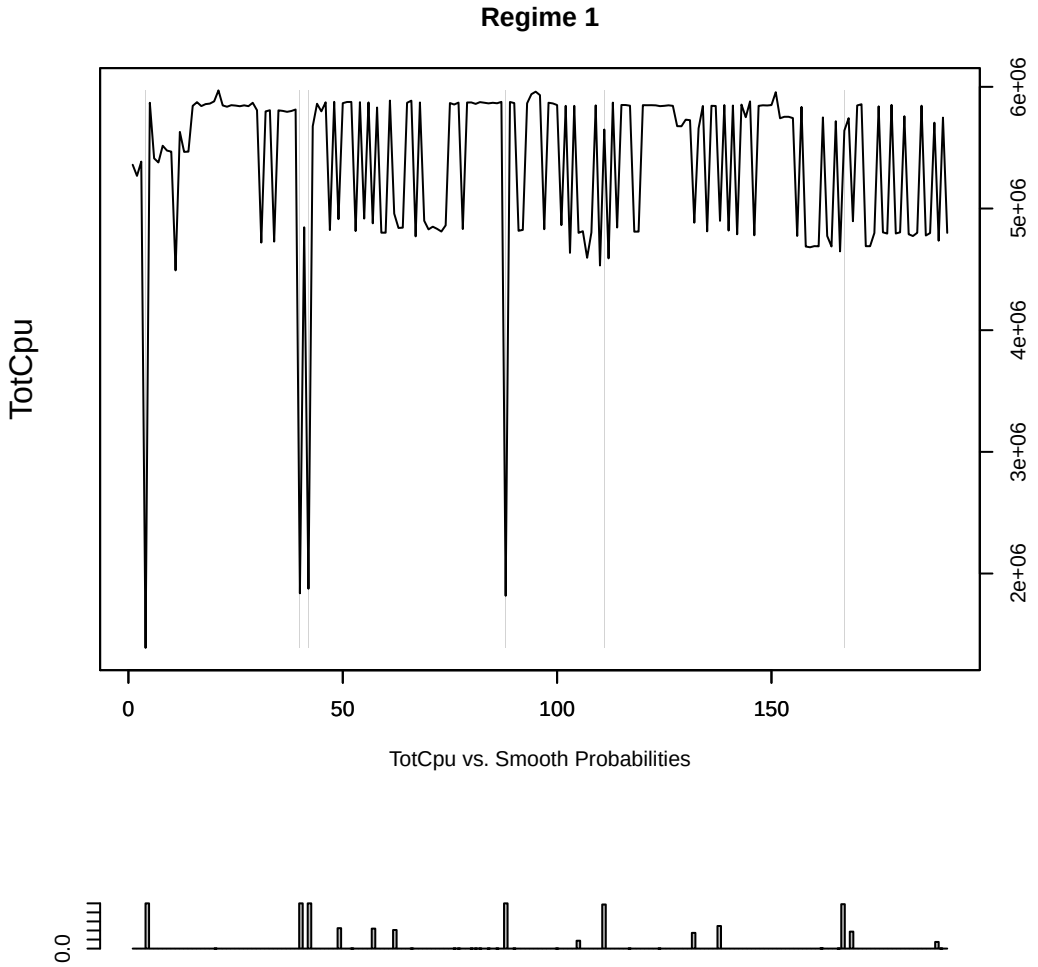

PACF of Residuals. Reg: 1
Partial ACF
1.0
0.5
0.0
−1.0
5
10
15
20
Lag

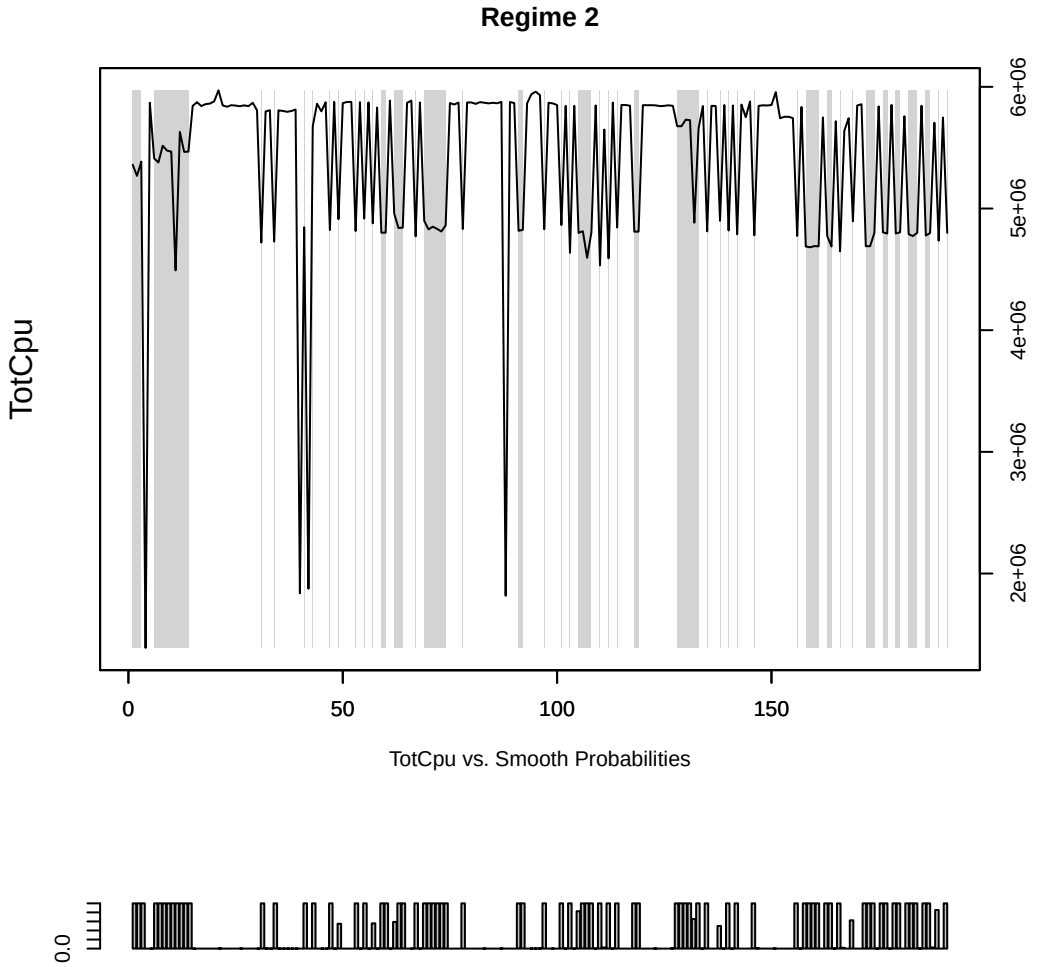

ACF of Square Resid. Reg: 1
ACF
1.0
0.5
0.0
−1.0
0
5
10
15
20
Lag

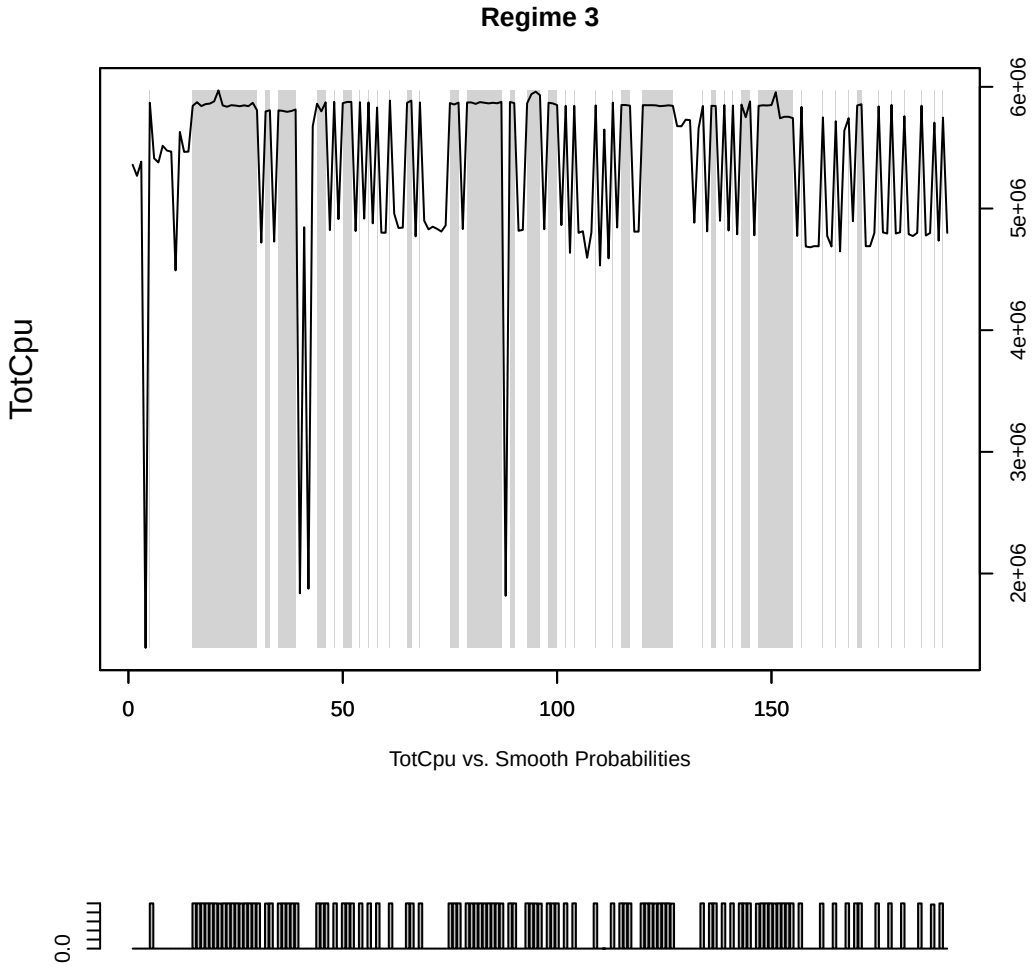

PACF of Square Resid. Reg: 1
Partial ACF
1.0
0.5
0.0
−1.0
5
10
15
20
Lag

plotProb: Plot of filtered and smoothed probabilities

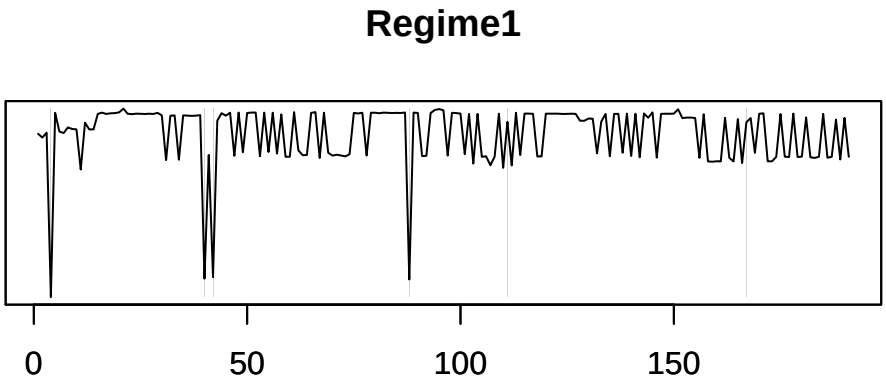



Regime 1
TotCpu
6e+06
5e+06
4e+06
3e+06
2e+06
0
50
100
150
TotCpu vs. Smooth Probabilities
0.0

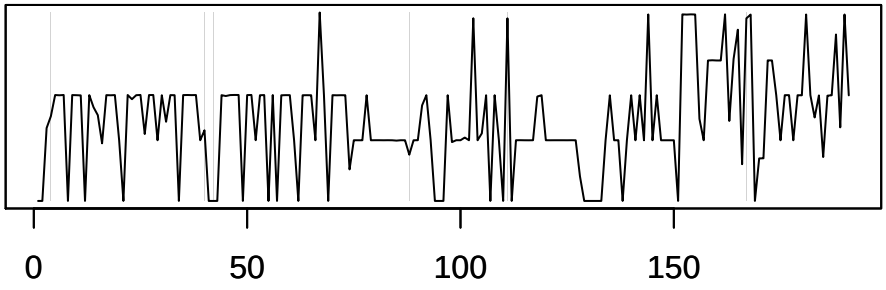

Regime 2
TotCpu
6e+06
5e+06
4e+06
3e+06
2e+06
0
50
100
150
TotCpu vs. Smooth Probabilities
0.0


Regime 3
TotCpu
6e+06
5e+06
4e+06
3e+06
2e+06
0
50
100
150
TotCpu vs. Smooth Probabilities
0.0

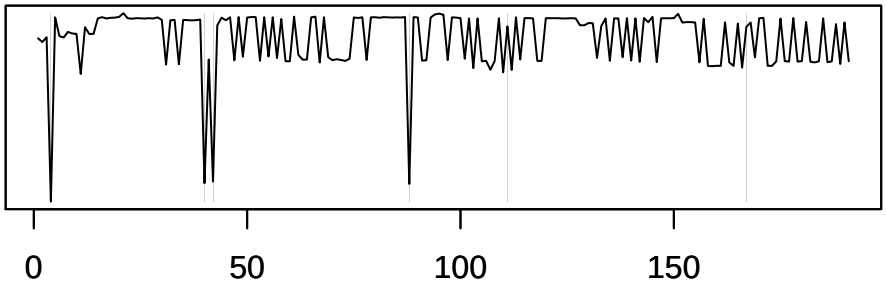
plotReg: Plot with the response and the explanatory variables with smoothed probabilities



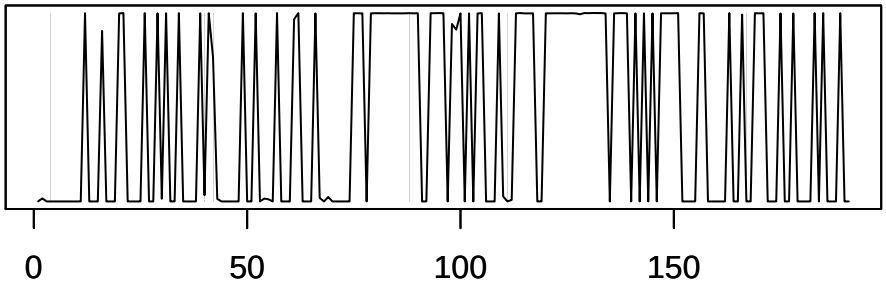
TotCpu with Smooth Probabilities



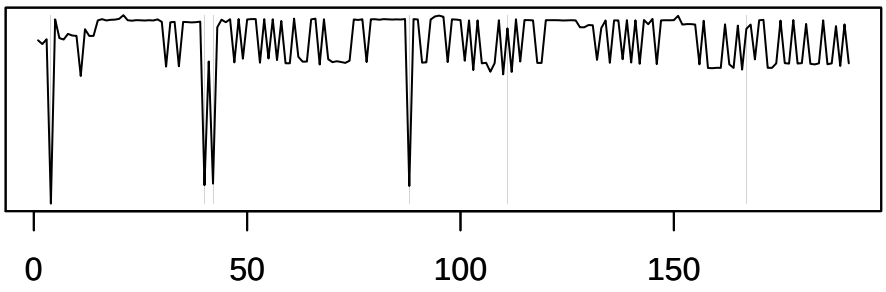
RrcConnectionSetupComplete with Smooth Probabilities



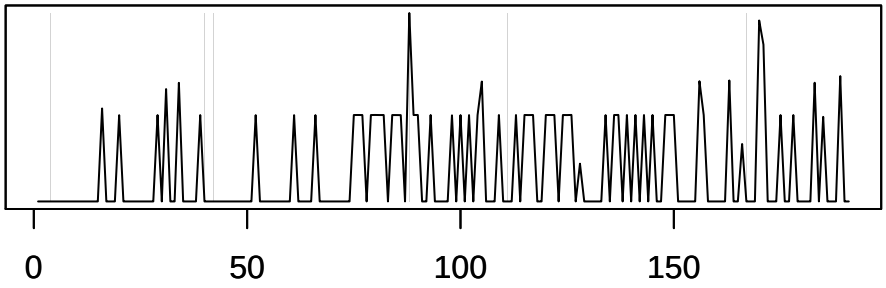
TotCpu with Smooth Probabilities



Paging with Smooth Probabilities



TotCpu with Smooth Probabilities



X2HandoverRequest with Smooth Probabilities

Modeling