Application

```
source("tmecArpRCO.R")
source("utils_tmecArpRCO.R")

library(mvtnorm)
library(mnormt)
library(lmec)
library(tmvtnorm)
library(msm)
library(ggplot2)
library(tcltk)
library(numDeriv)
library(MASS)
library(base)
library(expm)
library(ARpLMEC)


##############################################
# Dataset A5055                              #
##############################################
data1 <- read.csv("dataA5055.csv")

attach(data1)
data1 <- subset(data1, !is.na(cd4))
data1 <- subset(data1, !is.na(cd8))
subjects <- unique(data1$patid)
cluster <- c(match(data1$patid,subjects))
m <- length(subjects)
N <-length(cluster)
y1 <- c(data1$logrna)
y2.1 <- c(data1$cd4)
y2.2 <- c(data1$cd8)
y2 <- y2.1/y2.2
x<- c(data1$day)
tem=c(data1$day)
treat<-data1$arm
nj<-matrix(0,m,1)
for (j in 1:m) {
  nj[j]=sum(cluster==j)
}
cc<-(data1$rna<50)+0
y1[y1<=log10(50)] <- log10(50)


##############################################
# Excluded subject 4,8                       #
```

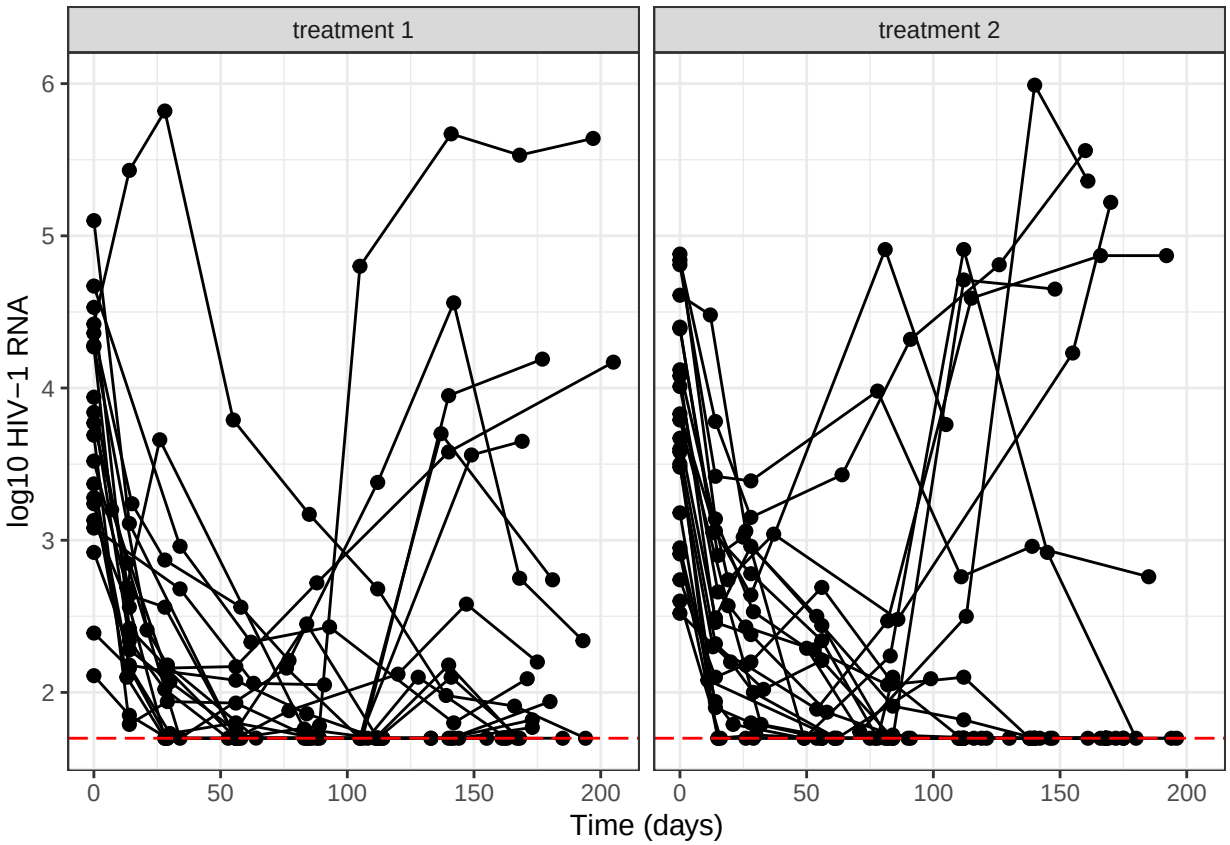
```
##########################################

for(i in c( 4,8))
{
  y1[cluster==i]= NA
  y2[cluster==i]= NA
  y2.1[cluster==i]= NA
  y2.2[cluster==i]= NA
  x[cluster==i]=NA
  tem[cluster==i]=NA
  treat[cluster==i]=NA
  cc[cluster==i]=NA
  nj[i]=NA
  cluster[cluster==i]=NA

}

paciente=data1$patid
paciente[paciente==150742]=NA
paciente[paciente==220747]=NA
paciente=as.vector(na.omit(paciente))


y1=as.vector(na.omit(y1))
y2=as.vector(na.omit(y2))
y2.1=as.vector(na.omit(y2.1))
y2.2=as.vector(na.omit(y2.2))
x=as.vector(na.omit(x))
tem=as.vector(na.omit(tem))
treat=as.vector(na.omit(treat))
cc=as.vector(na.omit(cc))
nj=as.vector(na.omit(nj))
cluster=as.vector(na.omit(cluster))

subjetos=unique(cluster)
for(i in 1:length(subjetos))
{
  cluster[cluster==subjetos[i]]=i
}

m <- length(nj)
N <-length(cluster)

##########################################
# Design matrix                          #
##########################################

xx1=cbind(rep(1,length(y1)),x,treat,y2.1^0.5,treat*x)
zz1=cbind(1,x)
cc1=cc
nj1=nj
y1=y1
tempo1=tem
```

Profiles Plot

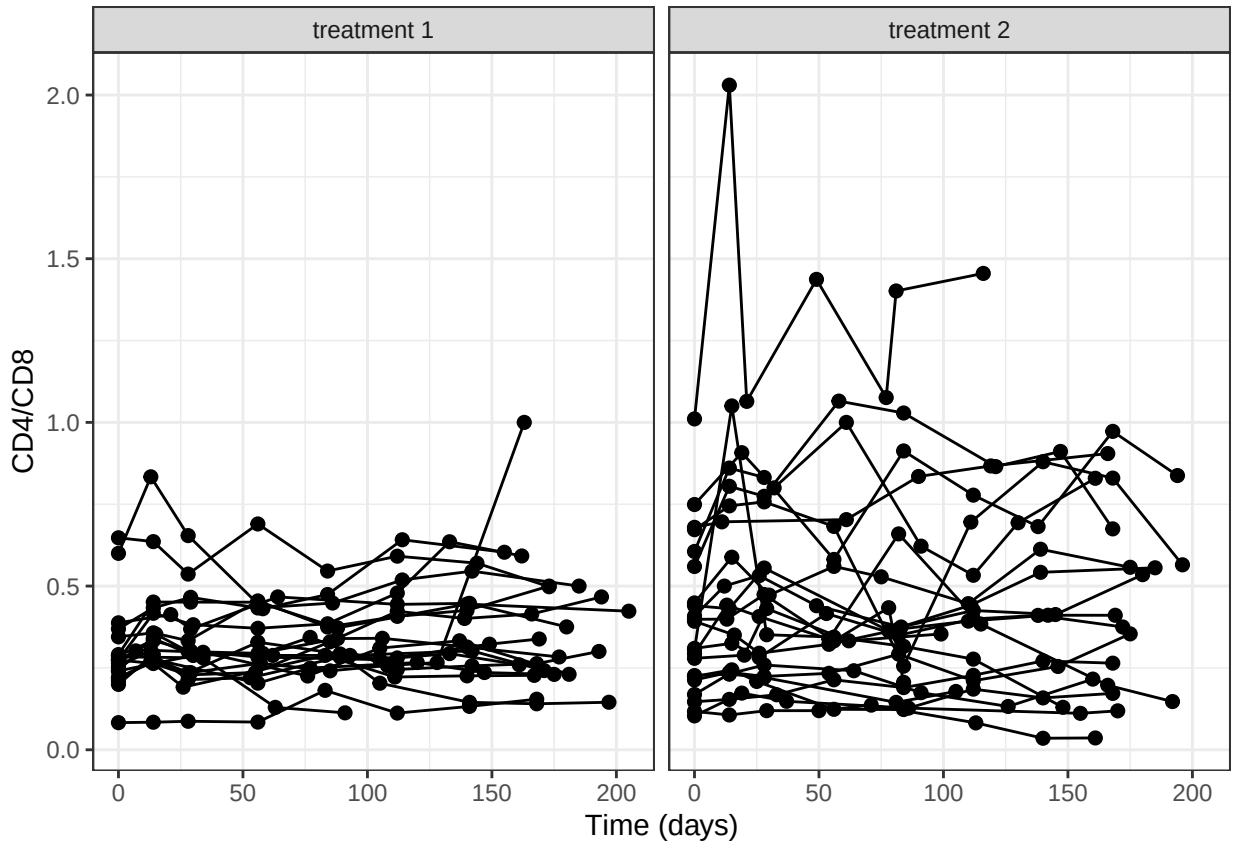
```
##########################################
#Profiles plot                           #
##########################################

datas <- cbind(paciente,cluster,treat,x,
               y1,y2,cc,y2.1)
nam_row=as.character((1:312))
nam_col=c("patid","cluster","arm","day","logrna","cd48","cens","cd4")
datas <- matrix(datas,nrow=312,ncol=8,dimnames=list(" "=nam_row," "=nam_col))
dados <- as.data.frame(datas)
attach(dados)

dados2 <- dados
dados2$arm[dados2$arm=="1"] <- "treatment 1"
dados2$arm[dados2$arm=="2"]   <- "treatment 2"
head(dados2, 3)
```

```
##   patid cluster         arm day  logrna      cd48 cens cd4
## 1 21360       1 treatment 1   0 2.11000 0.2878788    0 304
## 2 21360       1 treatment 1  14 1.85000 0.3336229    0 384
## 3 21360       1 treatment 1  29 1.69897 0.3018433    1 262
```

```
grafico <- ggplot(dados2, aes(x=day, y=logrna, group = cluster))
grafico + geom_line() +
  geom_point(size = 2) +
  labs(x = "Time (days)", y="log10 HIV-1 RNA") +
  facet_wrap(~ arm) +
  geom_hline(yintercept = log10(50), colour="red", linetype = "longdash") +
  theme_bw()
```




```
grafico2 <- ggplot(dados2, aes(x=day, y=cd48, group = cluster))
grafico2 + geom_line() +
  geom_point(size = 2) +
  labs(x = "Time (days)", y="CD4/CD8") +
  facet_wrap(~ arm) +
  theme_bw()
```



Initials values

```
##############################################
# Initials values                            #
##############################################

lm1.un1 <- ARpMMEC.est(y =y1 , x = xx1, z = zz1, tt = tempo1, cc =cc1,
                       nj = nj1, Arp = "UNC", error = 0.00001, MaxIter = 10)
```

```
##
## ----------------------------------------------------
## Autoregressive censored mixed-effects models
## ----------------------------------------------------
##
## Autoregressive order = UNC
## Subjects = 42 ; Observations = 312
##
## -----------
## Estimates
## -----------
##
## - Fixed effects
##
##           Est    SE          IConf(95%)
## beta 1  4.205 0.067   < 4.074 , 4.336 >
```

```
## beta 2 -0.003 0.009  < -0.021 , 0.015 >
## beta 3  0.270 0.248  < -0.216 , 0.756 >
## beta 4 -0.099 0.027 < -0.152 , -0.046 >
## beta 5 -0.001 0.005  < -0.011 , 0.009 >
##
##
## - Sigma^2
##
##           Est    SE       IConf(95%)
## Sigma^2 0.733 0.075 < 0.586 , 0.88 >
##
##
## - Random effects
##
##             Est    SE         IConf(95%)
## Alpha 11  0.337 0.202      < 0 , 0.733 >
## Alpha 12 -0.004 0.005 < -0.014 , 0.006 >
## Alpha 22  0.000 0.000          < 0 , 0 >
##
##
## ------------------------
## Model selection criteria
## ------------------------
##
##         Loglik     AIC     BIC   AICc
## Value -366.292 744.584 767.043 744.86
##
## -------
## Details
## -------
##
## Convergence reached? = FALSE
## Iterations = 10 / 10
## Processing time = 14.46062 secs
```

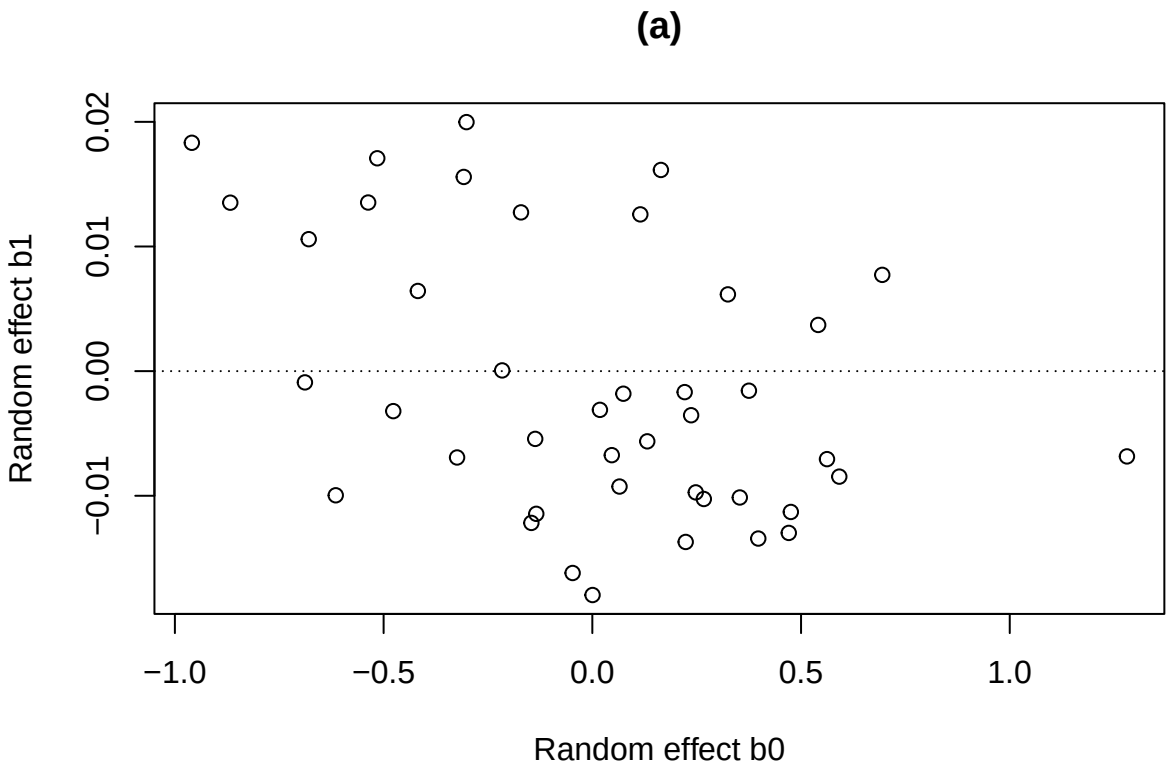
```
betasI <- as.vector(lm1.un1$FixEffec$Est)
sigma2I <- lm1.un1$Sigma2$Est
alphasI <- diag(2)
phi1I <- 0.1
phi2I <- 1
LL1 <- rep(-Inf,length(y1))
LU1 <- as.vector(y1)
```

```
##############################################
#  NLMEC Model with UNC                      #
##############################################
initial1 <- list(betas=betasI,sigma2=sigma2I,
                 alphas=alphasI,phi1=phi1I,phi2=phi2I,nu=150)
fitN<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                struc="unc",nu.fixed=TRUE,iter.max=500,precision=1e-4)
res<-fitY<-rep(0,length(y1))
efectob<-matrix(0,length(nj),2)
for (i in 1:length(nj)) {
  efectob[i,]=fitN$ubi[(((i-1)*2)+1) : (i*2),i]
```

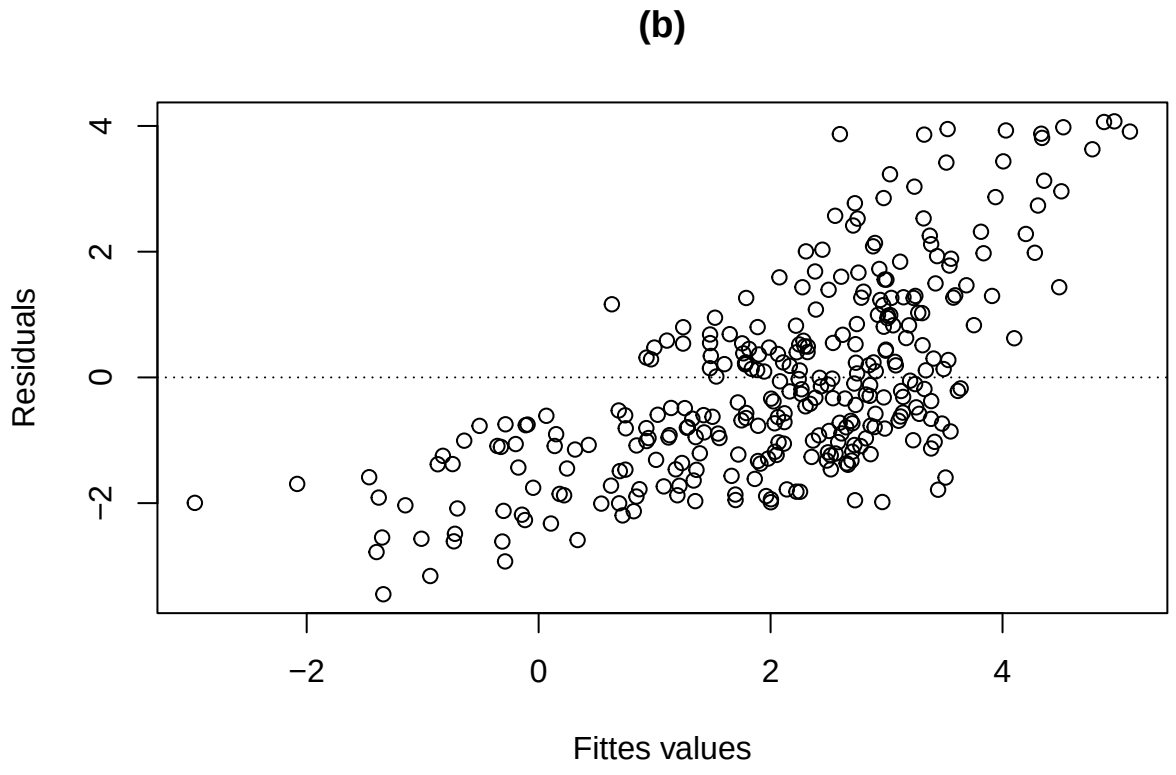
```
  resi<- fitN$yog[(sum(nj[1:i-1])+1) : (sum(nj[1:i]))]-
  xx1[(sum(nj[1:i-1])+1) : (sum(nj[1:i])),]%*%fitN$beta1
  res[(sum(nj[1:i-1])+1) : (sum(nj[1:i]))]<-((fitN$sigmae)^(-0.5))*resi
  fitY[(sum(nj[1:i-1])+1):(sum(nj[1:i]))]<-xx1[(sum(nj[1:i-1])+1):(sum(nj[1:i])),
                                              ]%*%fitN$beta1+
    zz1[(sum(nj[1:i-1])+1) : (sum(nj[1:i])),]%*%efectob[i,]
}
```

Residuals Plots for N-LMEC model with UNC structures

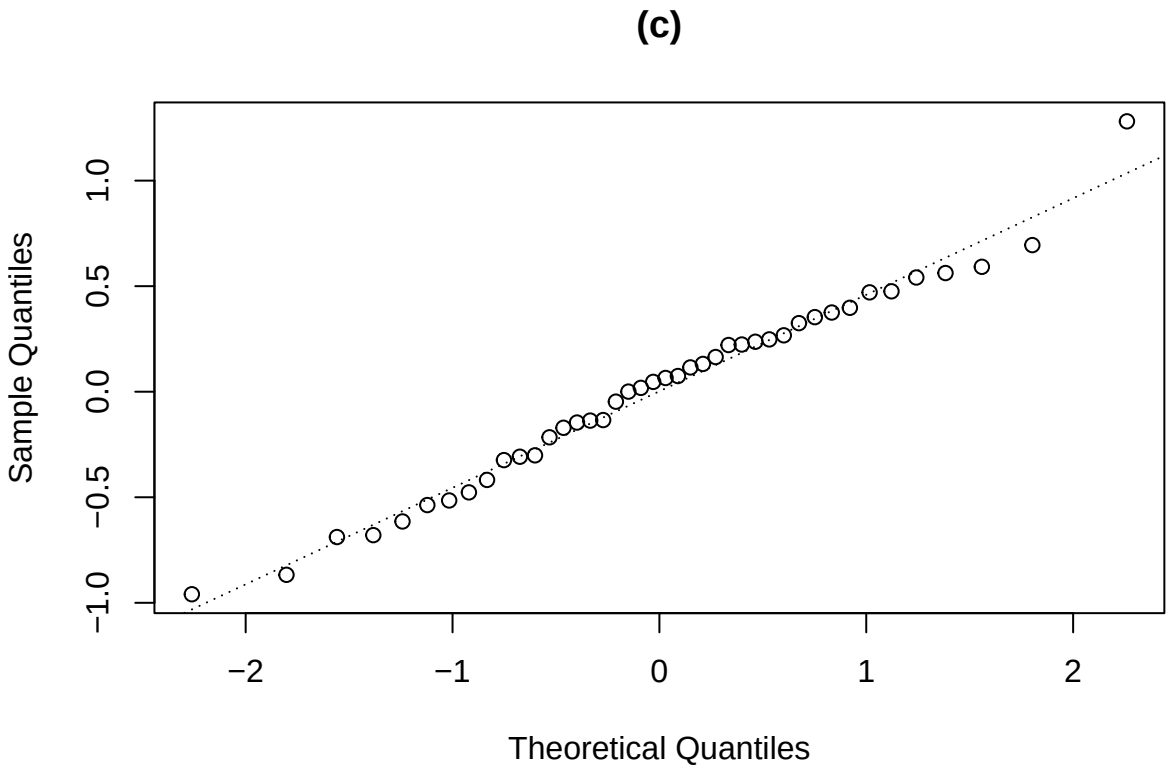
```
##########################################
# Residuals-NLMEC model                  #
##########################################

plot(efectob[,1],efectob[,2],xlab="Random effect b0",
     ylab="Random effect b1" ,main = "(a)")
abline(h=0, lty=3)
```



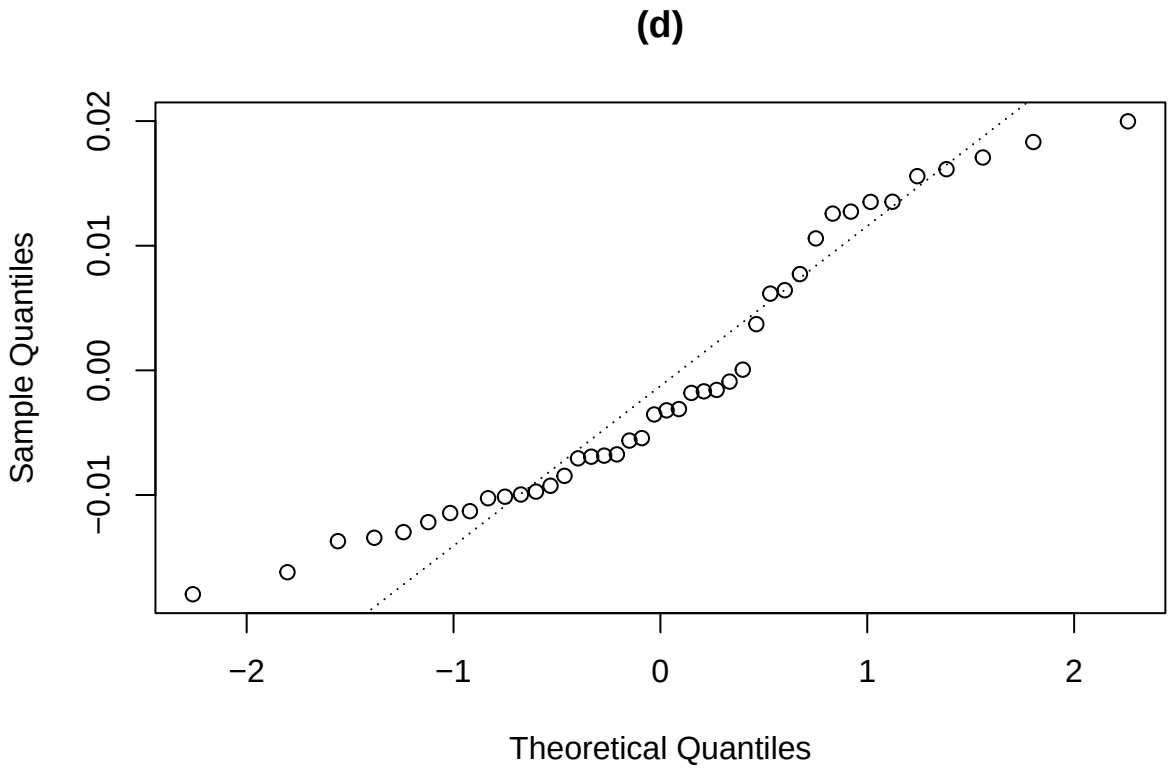

```
plot(fitY,res,xlab= "Fittes values", ylab= "Residuals", main="(b)")
abline(h=0, lty=3, col=9)
```




```
qqnorm(efectob[,1], main = "(c)")
qqline(efectob[,1], lty=3)
```

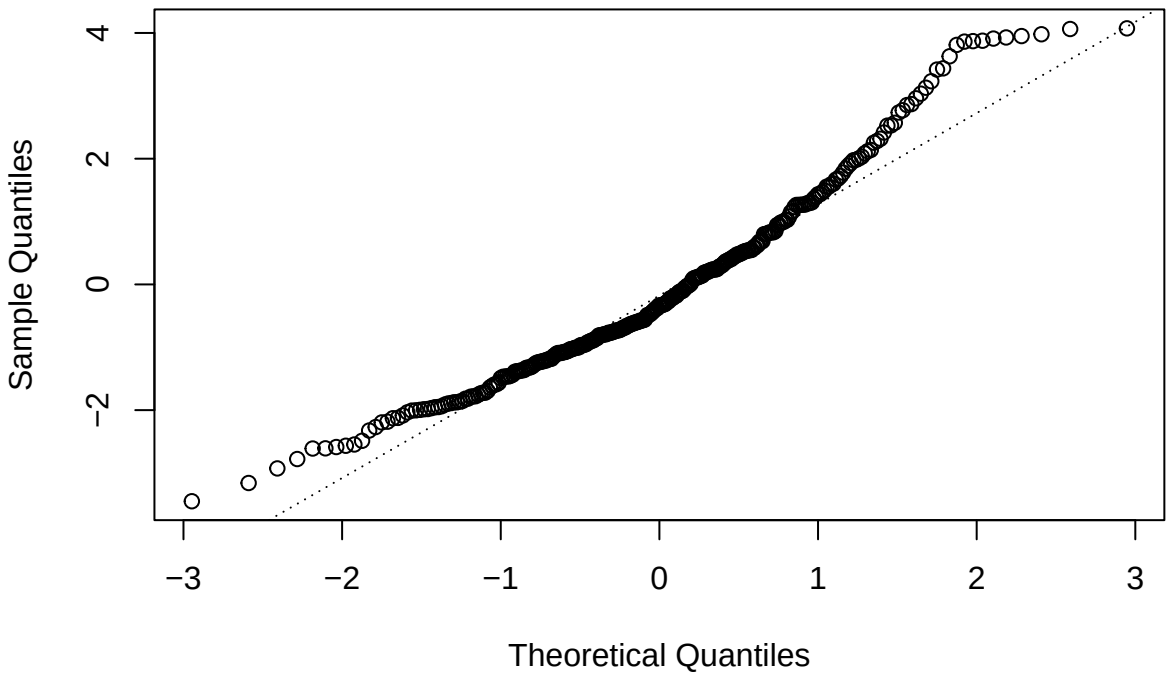



```
qqnorm(efectob[,2], main = "(d)")
qqline(efectob[,2], lty=3)
```




```
qqnorm(res ,main = "(e)")
qqline(res, lty=3)
```

(e)




```
################################################################
# tLMEC model under differents correlation structures      #
################################################################

initial1 <- list(betas=betasI,sigma2=sigma2I,
                 alphas=alphasI,phi1=phi1I,phi2=phi2I,nu=3)

######################### t (nu estimado)#####################
model1T1<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj1,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    struc="unc",nu.fixed=FALSE,iter.max=500,precision=1e-4)
model1T2<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    struc="dec",nu.fixed=FALSE,iter.max=500,precision=1e-4)
model1T3<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    struc="ar",nu.fixed=FALSE,iter.max=500,precision=1e-4)
model1T4<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    struc="sym",nu.fixed=FALSE,iter.max=500,precision=1e-4)
model1T5<- tmec.Arp(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    Arp=1,nu.fixed=FALSE,iter.max=500,precision=1e-4)
model1T6<- tmec.Arp(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    Arp=2,nu.fixed=FALSE,iter.max=500,precision=1e-4)
```

```
model1T7<- tmec.Arp(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    Arp=3,nu.fixed=FALSE,iter.max=500,precision=1e-4)
```

Estimation of Parameters under different t-LMEC Correlation Structures

```
############################################################

Table1Betas<-cbind(model1T1$beta1,model1T2$beta1,model1T3$beta1,
                   model1T4$beta1,model1T5$beta1,model1T6$beta1,
                   model1T7$beta1)
colnames(Table1Betas)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1sigmae<-cbind(model1T1$sigmae,model1T2$sigmae,model1T3$sigmae,
                    model1T4$sigmae,model1T5$sigmae,model1T6$sigmae,
                    model1T7$sigmae)
colnames(Table1sigmae)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1D<-cbind(model1T1$dd,model1T2$dd,model1T3$dd,
               model1T4$dd,model1T5$dd,model1T6$dd,model1T7$dd)
colnames(Table1D)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Phi1<-cbind(0,model1T2$phi1,model1T3$phi1,
                  model1T4$phi1,model1T5$phi,model1T6$phi[1],model1T7$phi[1])
colnames(Table1Phi1)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Phi2<-cbind(0,model1T2$phi2,model1T3$phi2,
                  model1T4$phi2,0,model1T6$phi[2],model1T7$phi[2])
colnames(Table1Phi2)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Phi3<-cbind(0,0,0,
                  0,0,0,model1T7$phi[3])
colnames(Table1Phi3)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Nu<-cbind(model1T1$nu,model1T2$nu,model1T3$nu,
                model1T4$nu,model1T5$nu,model1T6$nu,model1T7$nu)
colnames(Table1Nu)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

round(rbind(Table1Nu,Table1Betas,Table1sigmae,Table1D,
            Table1Phi1,Table1Phi2,Table1Phi3),4)
```

```
##           UNC     DEC  DEC-AR     SYM     AR1     AR2     AR3
##  [1,]  4.4800  4.5106  5.5038  4.5738  3.9094  4.2853  7.8919
##  [2,]  4.0373  4.0373  4.1106  4.0566  4.0351  4.0425  4.1505
##  [3,] -0.0047 -0.0046 -0.0041 -0.0047 -0.0047 -0.0046 -0.0042
##  [4,]  0.3462  0.3460  0.3777  0.3346  0.3489  0.3462  0.3481
##  [5,] -0.0884 -0.0884 -0.0956 -0.0894 -0.0885 -0.0888 -0.0984
##  [6,] -0.0039 -0.0038 -0.0041 -0.0035 -0.0039 -0.0038 -0.0039
##  [7,]  0.4841  0.4928  0.5343  0.5365  0.2882  0.2939  0.1708
##  [8,]  0.2348  0.2355  0.2283  0.2124  0.2348  0.2383  0.2355
##  [9,] -0.0018 -0.0018 -0.0020 -0.0019 -0.0018 -0.0018 -0.0020
```

```
## [10,]  0.0001  0.0001  0.0001  0.0001  0.0001  0.0001  0.0001
## [11,]  0.0000  0.1071  0.8993  0.0611  0.6462  0.7346  0.2761
## [12,]  0.0000  0.9976  1.0000  0.0000  0.0000 -0.4331  0.1095
## [13,]  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000 -0.8042
```

Model Selection Criterias under different t-LMEC Correlation Structures

```
##############Criterias TLMEC  model  ##################

Table1AIC<-cbind(model1T1$AIC,model1T2$AIC,model1T3$AIC,
                 model1T4$AIC,model1T5$AIC,model1T6$AIC,model1T7$AIC)
colnames(Table1AIC)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1BIC<-cbind(model1T1$BIC,model1T2$BIC,model1T3$BIC,
                 model1T4$BIC,model1T5$BIC,model1T6$BIC,model1T7$BIC)
colnames(Table1BIC)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1loglik<-cbind(model1T1$loglik,model1T2$loglik,model1T3$loglik,
                    model1T4$loglik,model1T5$loglik,model1T6$loglik,
                    model1T7$loglik)
colnames(Table1loglik)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

rbind(Table1loglik,Table1AIC,Table1BIC)
```

```
##            UNC       DEC    DEC-AR       SYM       AR1       AR2       AR3
## [1,] -355.6178 -355.6712 -350.7083 -355.9217 -355.5242 -355.6777 -352.888
## [2,]  731.2357  735.3424  723.4167  733.8435  733.0484  735.3554  731.776
## [3,]  768.6657  780.2585  764.5897  775.0165  774.2215  780.2714  780.435
```

```
#####################################################################
# Model NLMEC under differents correlation structures              #
#####################################################################
initial1 <- list(betas=betasI,sigma2=sigma2I,
                 alphas=alphasI,phi1=phi1I,phi2=phi2I,nu=150)
######################## df=150 ###################
model1N11<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                     ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                     struc="unc",nu.fixed=TRUE,iter.max=500,precision=1e-4)
model1N12<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                     ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                     struc="dec",nu.fixed=TRUE,iter.max=500,precision=1e-4)
model1N13<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                     ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                     struc="ar",nu.fixed=TRUE,iter.max=500,precision=1e-4)
model1N14<- tmec.DEC(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                     ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                     struc="sym",nu.fixed=TRUE,iter.max=500,precision=1e-4)
model1N15<- tmec.Arp(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                     ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                     Arp=1,nu.fixed=TRUE,iter.max=500,precision=1e-4)
model1N16<- tmec.Arp(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                     ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
```

```
                    Arp=2,nu.fixed=TRUE,iter.max=500,precision=1e-4)
model1N17<- tmec.Arp(y=y1,cc=cc1,x=xx1,z=zz1,nj=nj,
                    ttc=tempo1,LL=LL1,LU=LU1,initial=initial1,
                    Arp=3,nu.fixed=TRUE,iter.max=500,precision=1e-4)
```

Estimation of Parameters under different N-LMEC Correlation Structures

```
#####################################################################
Table1Betas<-cbind(model1N11$beta1,model1N12$beta1,model1N13$beta1,
                   model1N14$beta1,model1N15$beta1,model1N16$beta1,
                   model1N17$beta1)
colnames(Table1Betas)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1sigmae<-cbind(model1N11$sigmae,model1N12$sigmae,model1N13$sigmae,
                    model1N14$sigmae,model1N15$sigmae,model1N16$sigmae,
                    model1N17$sigmae)
colnames(Table1sigmae)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1D<-cbind(model1N11$dd,model1N12$dd,model1N13$dd,
               model1N14$dd,model1N15$dd,model1N16$dd,model1N17$dd)
colnames(Table1D)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Phi1<-cbind(0,model1N12$phi1,model1N13$phi1,
                  model1N14$phi1,model1N15$phi,model1N16$phi[1],
                  model1N17$phi[1])
colnames(Table1Phi1)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Phi2<-cbind(0,model1N12$phi2,model1N13$phi2,
                  model1N14$phi2,0,model1N16$phi[2],model1N17$phi[2])
colnames(Table1Phi2)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Phi3<-cbind(0,0,0,
                  0,0,0,model1N17$phi[3])
colnames(Table1Phi3)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1Nu<-cbind(model1N11$nu,model1N12$nu,model1N13$nu,
                model1N14$nu,model1N15$nu,model1N16$nu,model1N17$nu)
colnames(Table1Nu)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

round(rbind(Table1Nu,Table1Betas,Table1sigmae,Table1D,Table1Phi1,
            Table1Phi2,Table1Phi3),4)
```

```
##            UNC      DEC   DEC-AR      SYM      AR1      AR2      AR3
##  [1,] 150.0000 150.0000 150.0000 150.0000 150.0000 150.0000 150.0000
##  [2,]   4.3645   4.3644   4.3452   4.3711   4.3653   4.3642   4.2916
##  [3,]  -0.0040  -0.0039  -0.0033  -0.0040  -0.0040  -0.0039  -0.0033
##  [4,]   0.3054   0.3055   0.3542   0.3056   0.3096   0.3083   0.3610
##  [5,]  -0.1096  -0.1096  -0.1129  -0.1101  -0.1099  -0.1099  -0.1124
##  [6,]  -0.0029  -0.0029  -0.0033  -0.0030  -0.0030  -0.0029  -0.0036
##  [7,]   0.7134   0.7135   0.7245   0.7451   0.4130   0.4076   0.1908
##  [8,]   0.3751   0.3750   0.3258   0.3459   0.3741   0.3765   0.2988
```

```
##  [9,]  -0.0039  -0.0039  -0.0037  -0.0039  -0.0039  -0.0039  -0.0031
## [10,]   0.0002   0.0002   0.0002   0.0002   0.0002   0.0002   0.0002
## [11,]   0.0000   0.1061   0.8993   0.0426   0.6552   0.7603   0.2755
## [12,]   0.0000   0.9980   1.0000   0.0000   0.0000  -0.4809   0.0998
## [13,]   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000  -0.8167
```

Model Selection Criterias under different N-LMEC Correlation Structures

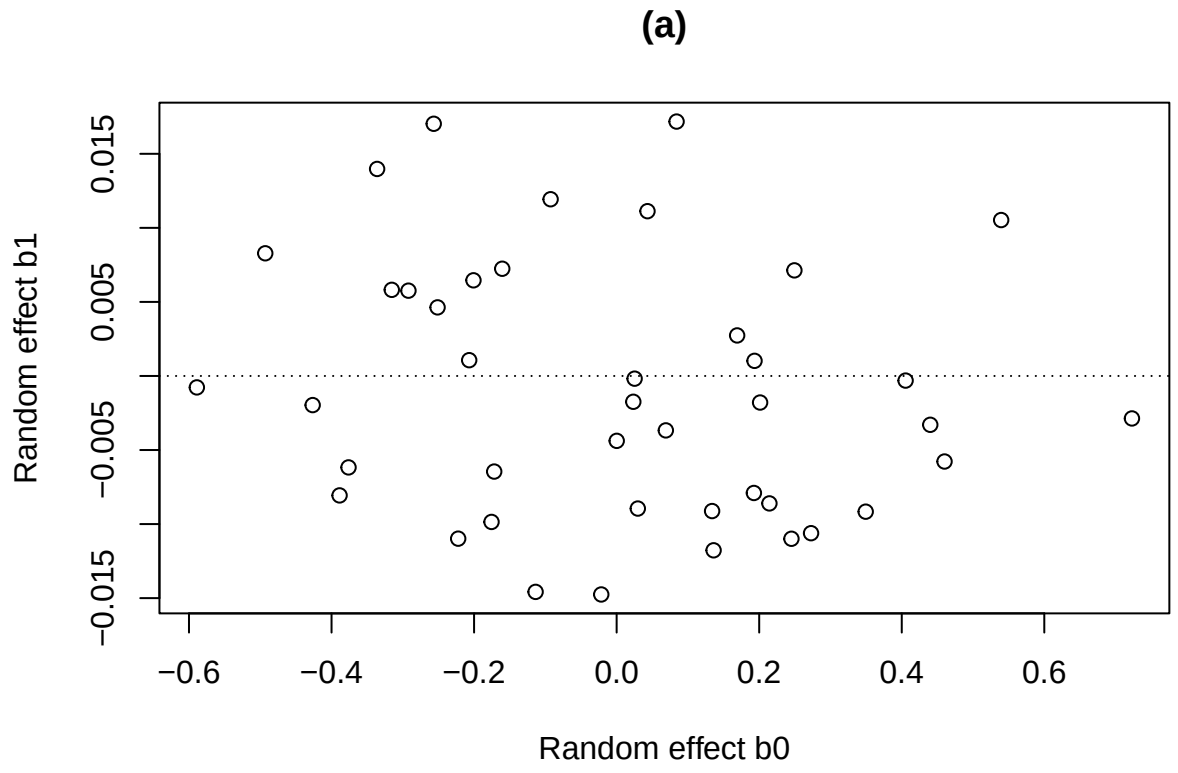
```
##############Criterias NLMEC  model ##################

Table1AIC1<-cbind(model1N11$AIC,model1N12$AIC,model1N13$AIC,
                  model1N14$AIC,model1N15$AIC,model1N16$AIC,model1N17$AIC)
colnames(Table1AIC1)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1BIC1<-cbind(model1N11$BIC,model1N12$BIC,model1N13$BIC,
                  model1N14$BIC,model1N15$BIC,model1N16$BIC,model1N17$BIC)
colnames(Table1BIC1)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

Table1loglik1<-cbind(model1N11$loglik,model1N12$loglik,model1N13$loglik,
                     model1N14$loglik,model1N15$loglik,model1N16$loglik,
                     model1N17$loglik)
colnames(Table1loglik1)=c("UNC","DEC","DEC-AR","SYM","AR1","AR2","AR3")

rbind(Table1loglik1,Table1AIC1,Table1BIC1)
```

```
##            UNC       DEC    DEC-AR       SYM       AR1       AR2       AR3
## [1,] -362.0539 -362.0544 -354.9449 -361.9951 -361.7947 -361.8775 -355.0889
## [2,]  744.1078  748.1089  731.8897  745.9902  745.5894  747.7549  736.1778
## [3,]  781.5378  793.0249  773.0628  787.1633  786.7624  792.6709  784.8368
```

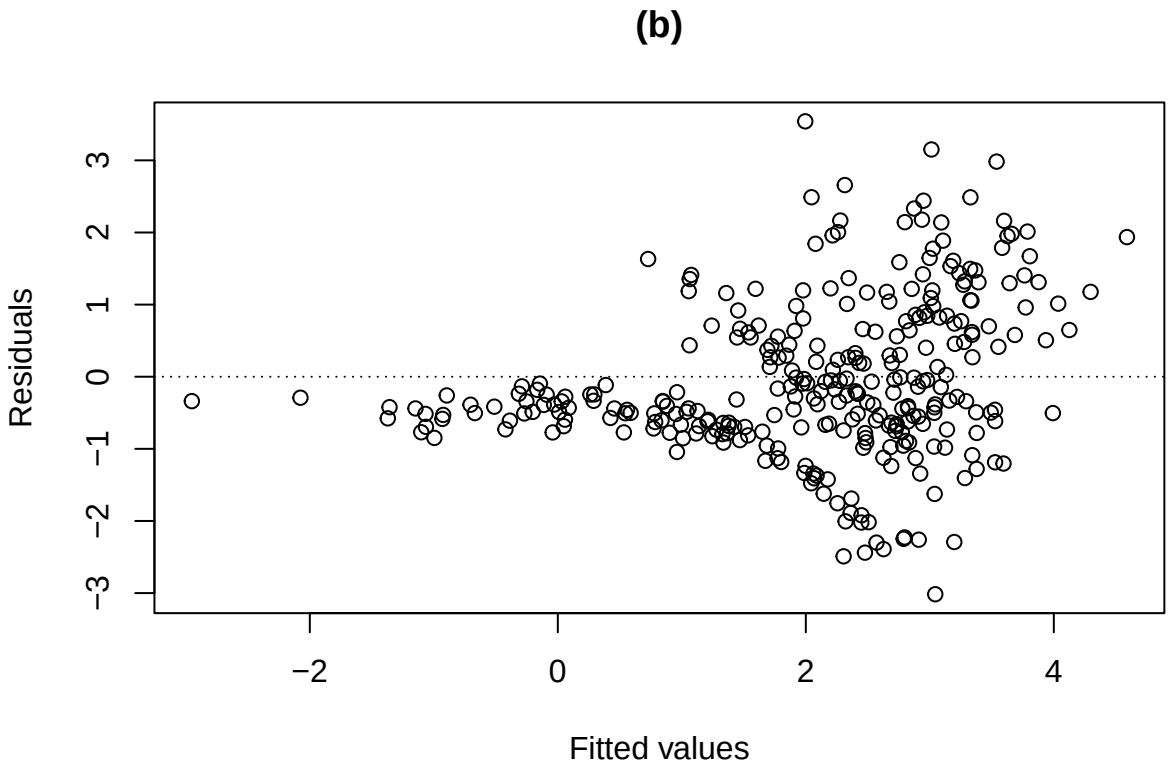
Residuals Pltos under t-LMEC DEC(AR) Structures

```
###########################################
# Residue analysis   DEc(AR) tLMEC        #
###########################################
obj=model1T3
Di<-matrix(0,dim(zz1)[2],dim(zz1)[2])
bet<-obj$beta1
Di[upper.tri(Di, diag = T)]<-obj$dd
Di[lower.tri(Di, diag = T)]<-obj$dd
Di<-round(Di,6)
sig<-obj$sigmae
rese <-Yi<-Ye<- vector(mode = "numeric", length = length(y1))
efectob<-matrix(0,length(nj),2)
for (k in 1:length(nj))
{ tc<-tem[(sum(nj[1:k-1])+1) : (sum(nj[1:k]))]
  bi<-obj$ubi[(((k-1)*dim(zz1)[2])+1) : (k*dim(zz1)[2]), k]
  efectob[k,]=bi
  Mq<-MatDec(tc,obj$phi1,obj$phi2,"ar")
  Sii<-zz1[(sum(nj[1:k-1])+1) : (sum(nj[1:k])),]%*%Di%*%
    t(zz1[(sum(nj[1:k-1])+1) : (sum(nj[1:k])),])+sig*Mq
```

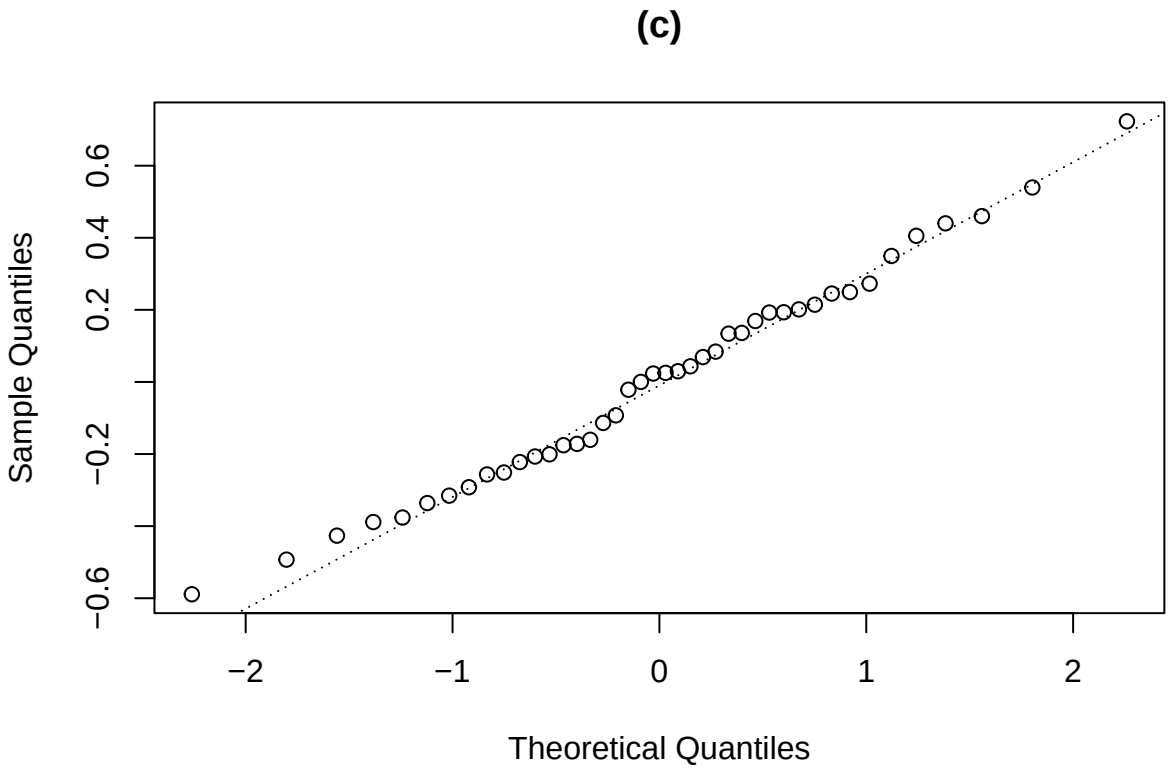
```
  Sii<-round(Sii,6)
  Mui<-xx1[(sum(nj[1:k-1])+1) : (sum(nj[1:k])),]%*%bet
  Yi<-obj$yog[(sum(nj[1:k-1])+1) : (sum(nj[1:k]))]
  Ye[(sum(nj[1:k-1])+1):(sum(nj[1:k]))]<-xx1[(sum(nj[1:k-1])+1):(sum(nj[1:k])),
                                          ]%*%bet+
    zz1[(sum(nj[1:k-1])+1) : (sum(nj[1:k])),]%*%bi
  rese[(sum(nj[1:k-1])+1) : (sum(nj[1:k]))]=(sqrtm(solve(Sii))%*%(Yi-Mui))
 }


plot(efectob[,1],efectob[,2],xlab="Random effect b0",
     ylab="Random effect b1",main="(a)")
abline(h=0, lty=3)
```



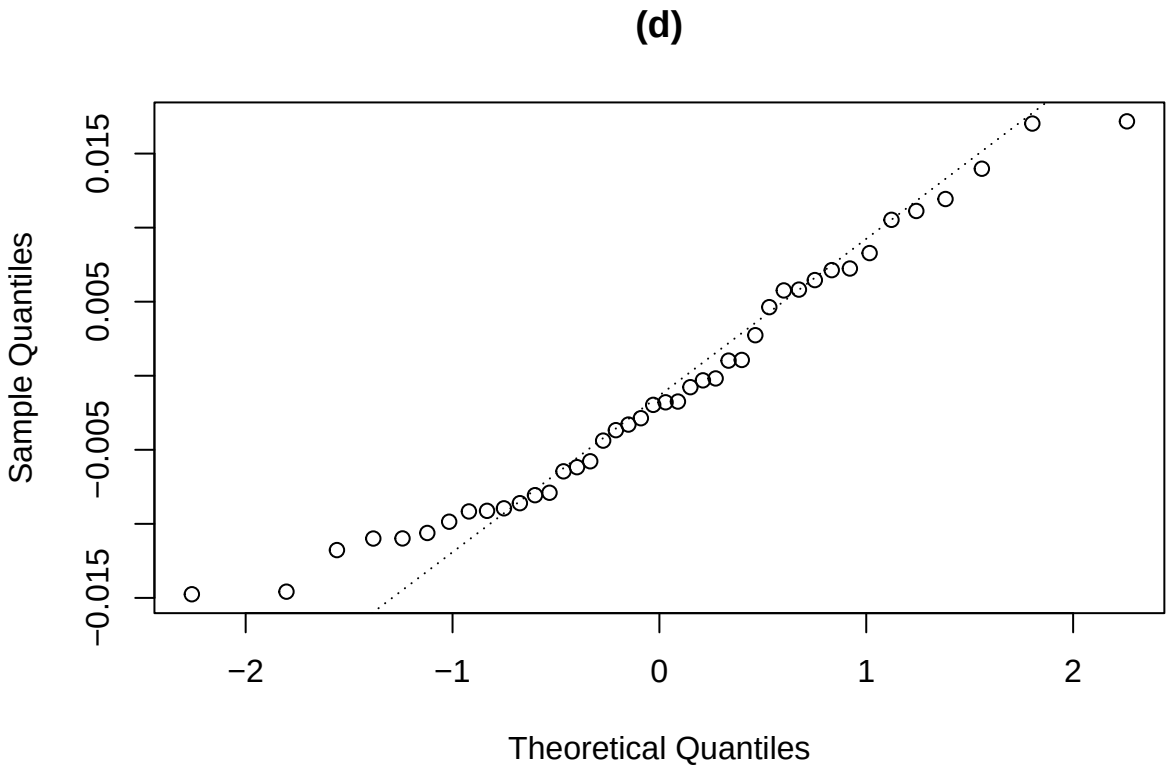

```
plot(Ye,rese,xlab= "Fitted values", ylab= "Residuals",main = "(b)")
abline(h=0, lty=3, col=9)
```




```
qqnorm(efectob[,1], main = "(c)")
qqline(efectob[,1], lty=3)
```

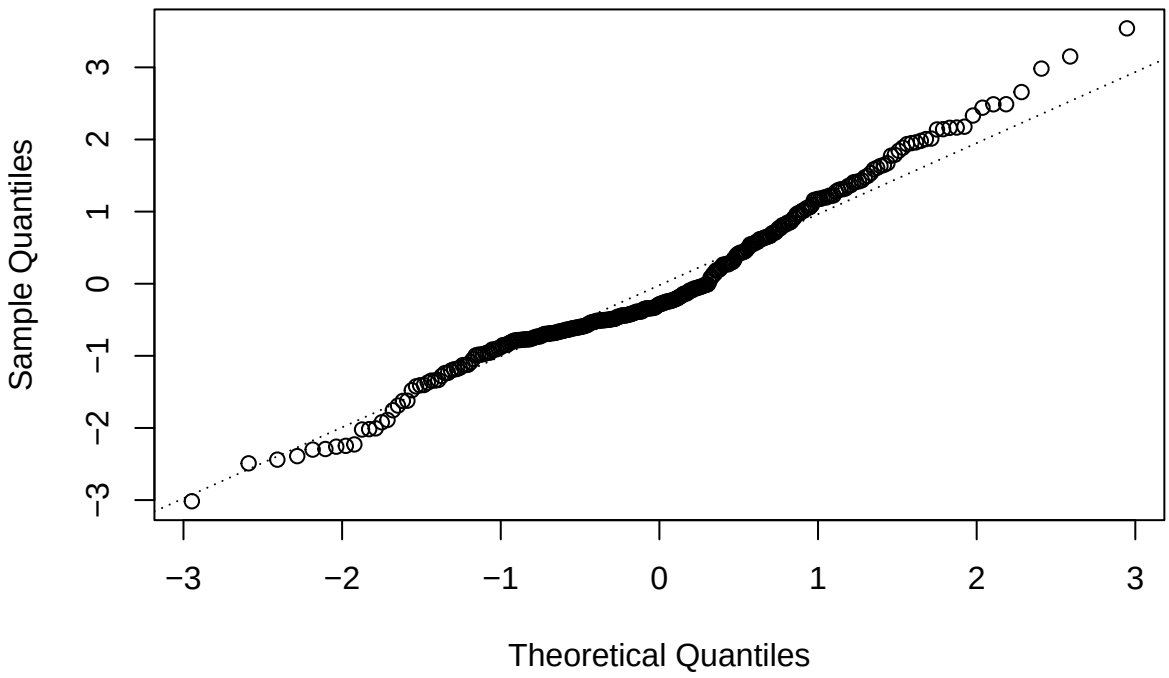



```
qqnorm(efectob[,2],main = "(d)")
qqline(efectob[,2], lty=3)
```




```
qqnorm(rese,main = "(e)")
qqline(rese, lty=3)
```

(e)




```
round(cbind(sqrt(diag(solve(model1T1$Infbetas))),
sqrt(diag(solve(model1T2$Infbetas))),
sqrt(diag(solve(model1T3$Infbetas))),
sqrt(diag(solve(model1T4$Infbetas))),
sqrt(diag(solve(model1T5$Infbetas))),
sqrt(diag(solve(model1T6$Infbetas))),
sqrt(diag(solve(model1T7$Infbetas)))),4)
```

```
##        [,1]   [,2]   [,3]   [,4]   [,5]   [,6]   [,7]
## [1,] 0.4978 0.5023 0.5207 0.5043 0.5032 0.5027 0.5419
## [2,] 0.0072 0.0072 0.0074 0.0073 0.0072 0.0072 0.0076
## [3,] 0.2472 0.2496 0.2622 0.2512 0.2497 0.2496 0.2718
## [4,] 0.0193 0.0194 0.0199 0.0194 0.0195 0.0194 0.0202
## [5,] 0.0048 0.0048 0.0049 0.0048 0.0048 0.0048 0.0050
```

```
round(cbind(sqrt(diag(solve(model1N11$Infbetas))),
sqrt(diag(solve(model1N12$Infbetas))),
sqrt(diag(solve(model1N13$Infbetas))),
sqrt(diag(solve(model1N14$Infbetas))),
sqrt(diag(solve(model1N15$Infbetas))),
sqrt(diag(solve(model1N16$Infbetas))),
sqrt(diag(solve(model1N17$Infbetas)))),4)
```

```
##        [,1]   [,2]   [,3]   [,4]   [,5]   [,6]   [,7]
## [1,] 0.4960 0.4960 0.5013 0.4969 0.4982 0.4981 0.5182
## [2,] 0.0073 0.0073 0.0073 0.0073 0.0073 0.0073 0.0075
## [3,] 0.2561 0.2561 0.2616 0.2566 0.2572 0.2571 0.2671
```

```
## [4,] 0.0187 0.0187 0.0186 0.0187 0.0188 0.0188 0.0191
## [5,] 0.0047 0.0047 0.0047 0.0047 0.0047 0.0047 0.0048
```