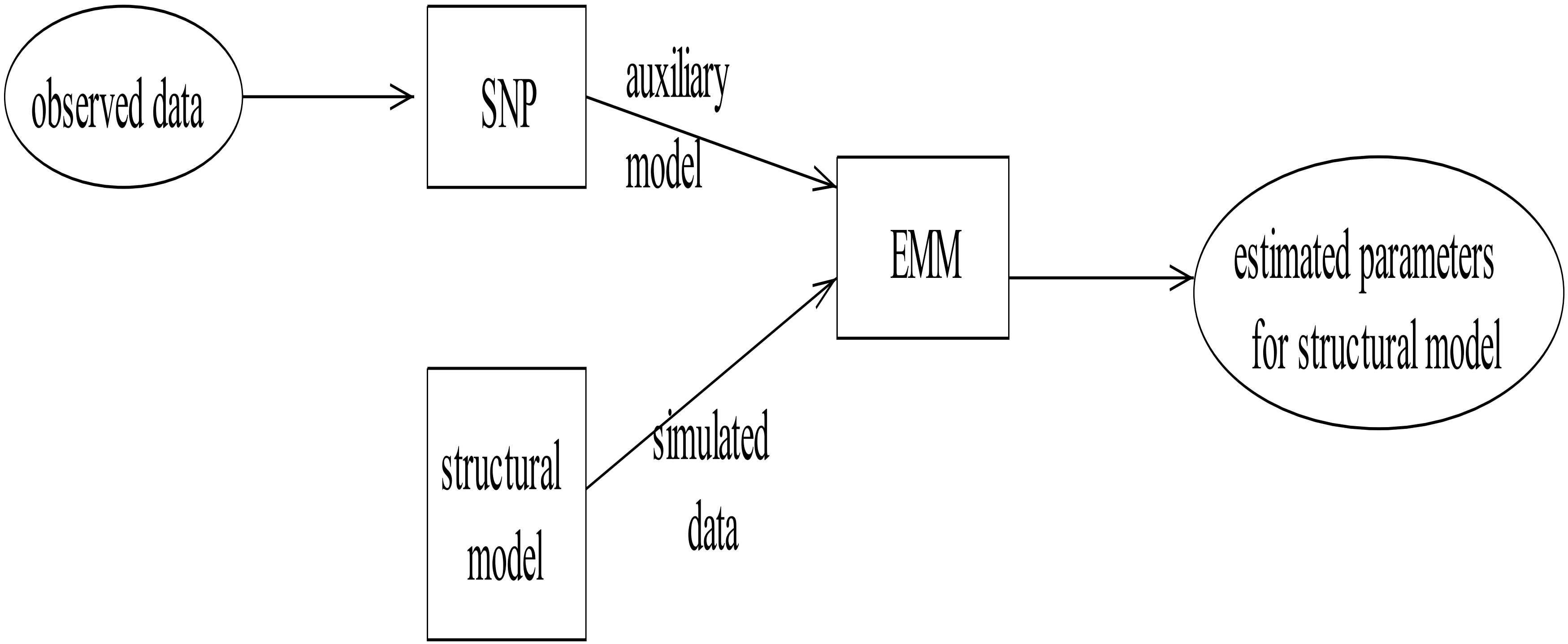
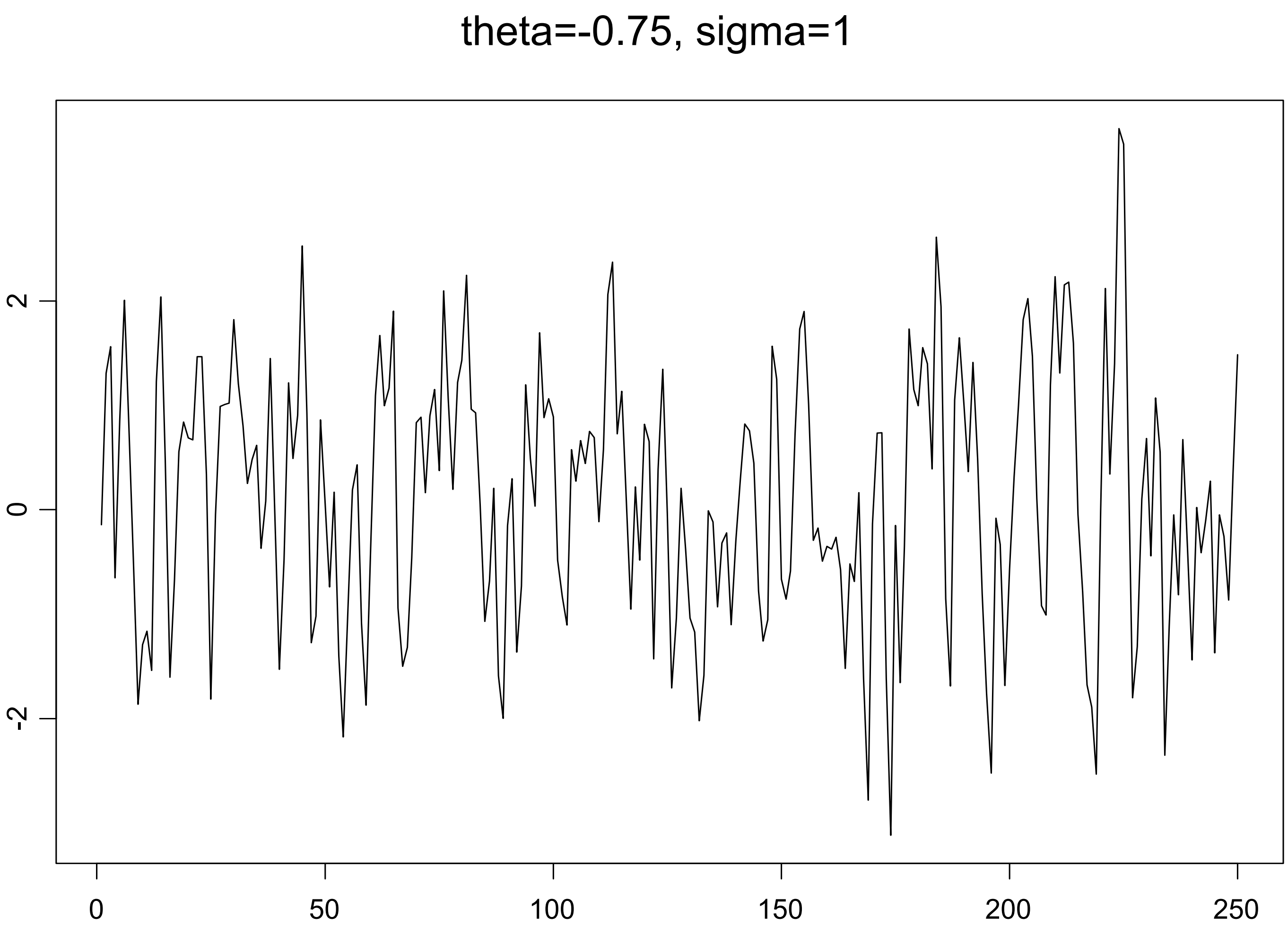
EMM Flow Diagram



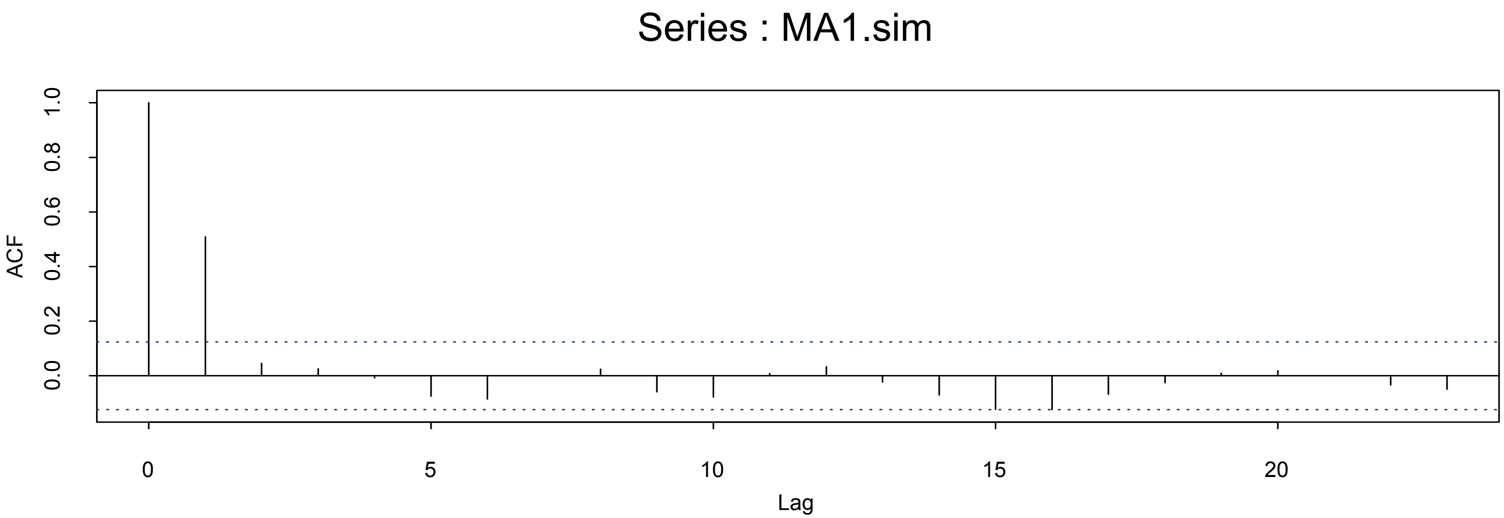
Simulate MA(1) Data Using `gensim` Function

```
MA1.gensim <- function(rho, n.sim=100, n.var=1, n.burn=25,
                        aux=NULL) {
# simulate from MA(1) model
# y(t) = e(t) - theta*e(t-1), e(t) ~ iid N(0,sigma^2)
# rho = (theta,sigma2)'
# aux is a list with components
#  innov = standard normals used for simulation
#  start.innov = standard normals used for start up values

     ans = arima.sim(model = list(ma=rho[1]),
           innov = aux$innov*sqrt(rho[2]),
           start.innov = aux$innov.start*sqrt(rho[2]))
   ans
}
```

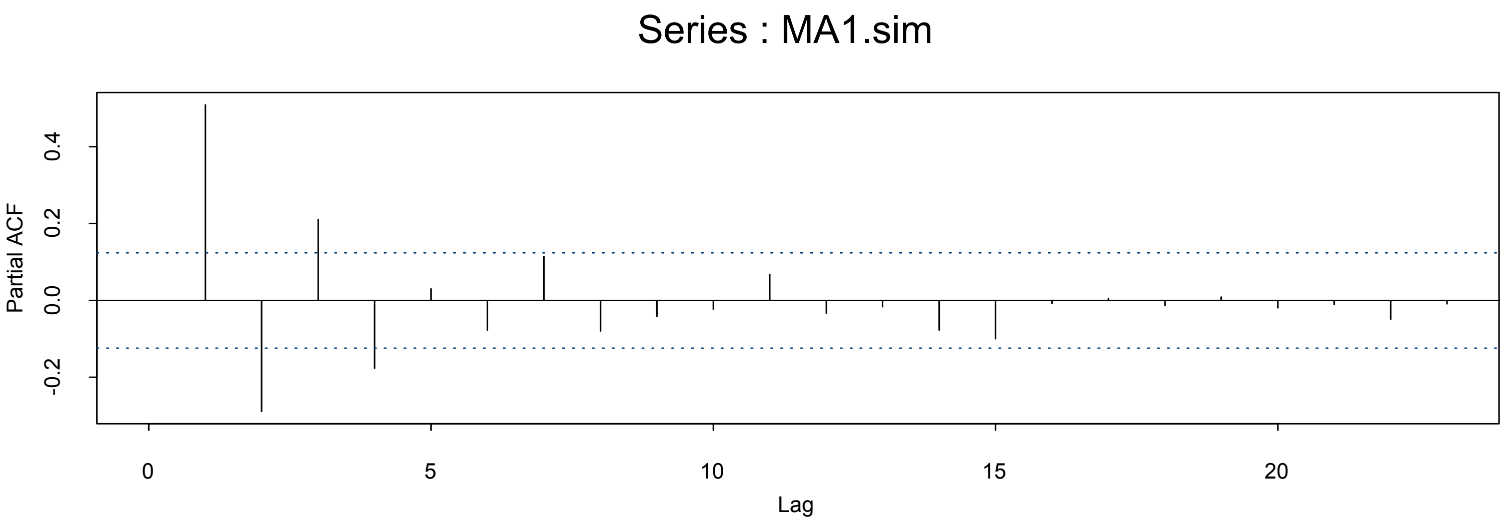
MA(1) Data



MA(1) Data



Series : MA1.sim
ACF
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
Lag



Series : MA1.sim
Partial ACF
-0.2
0.0
0.2
0.4
0
5
10
15
20
Lag

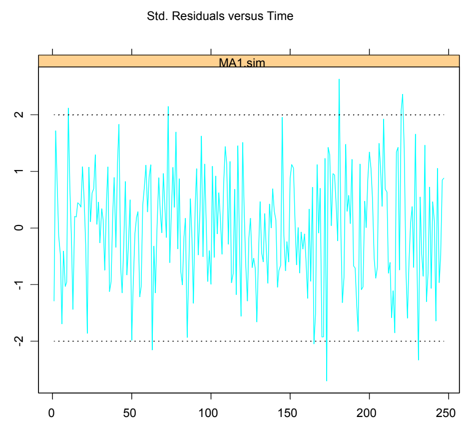
MLE of MA(1)

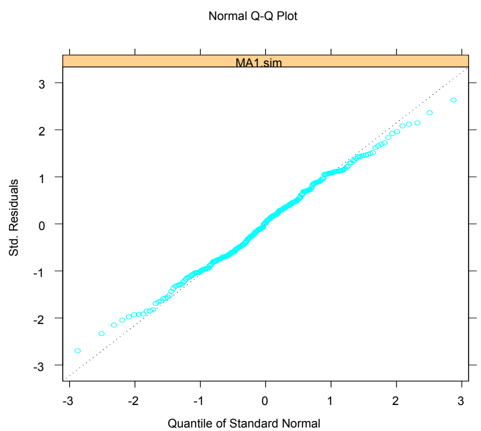
```
> MA1.data = MA1.sim - mean(MA1.sim)
> mle.fit = arima.mle(MA1.data,model=list(ma=-0.5))
> mle.fit

Coefficients:
      MA : -0.76773

> mle.fit$sigma2
[1] 0.8854201

> sqrt(mle.fit$var.coef)
           ma(1)
ma(1) 0.04052596
```

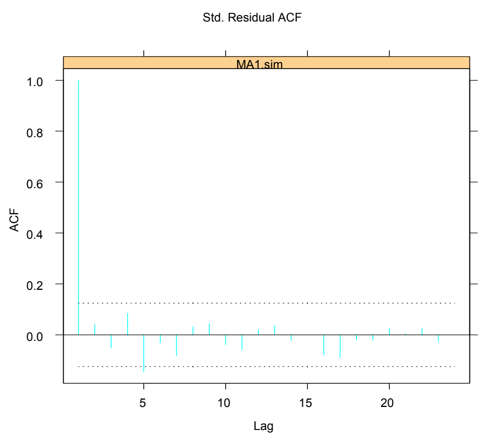
Fit AR(3) Auxiliary Model

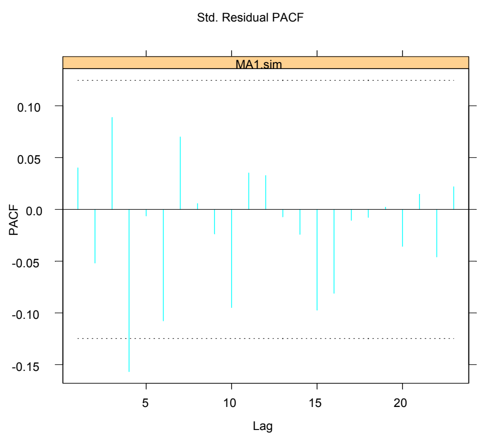
```
> ar3.fit = SNP(data=MA1.sim, model=SNP.model(ar=3))
> class(ar3.fit)
[1] "SNP"
> summary(ar3.fit)
Model: Gaussian VAR

Conditional Mean Coefficients:
                 mu     ar(1)     ar(2)     ar(3)
     coef   -0.0039    0.7205   -0.4307    0.2114
(std.err)    0.0517    0.0626    0.0672    0.0630
 (t.stat)   -0.0749   11.5170   -6.4077    3.3549

Conditional Variance Coefficients:
             sigma2
     coef   0.8052
(std.err)   0.0424
 (t.stat)  19.0124
```

Auxiliary Model Diagnostics



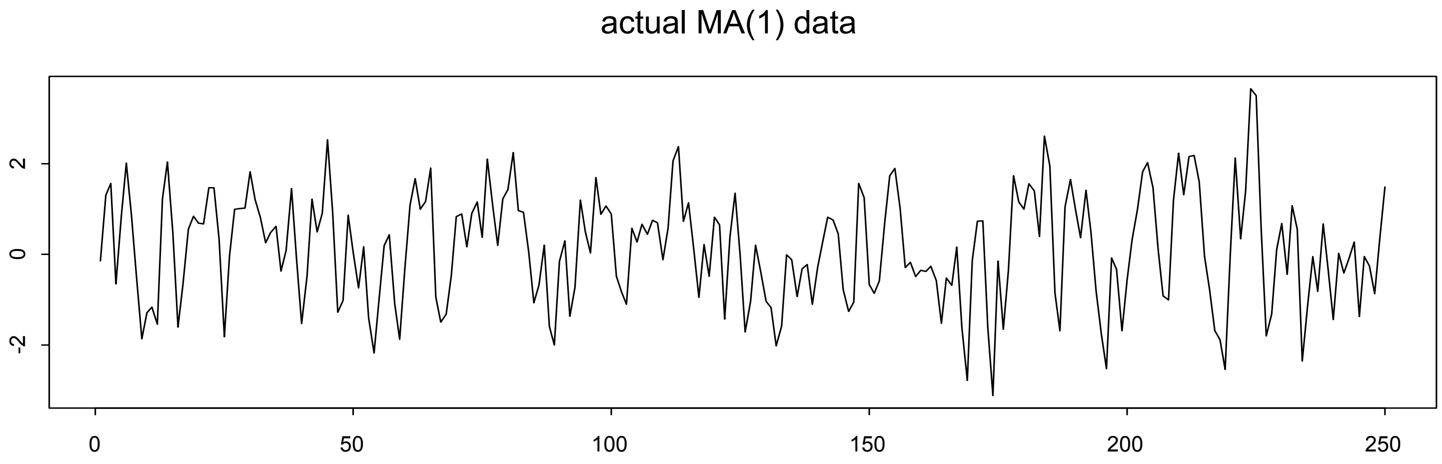


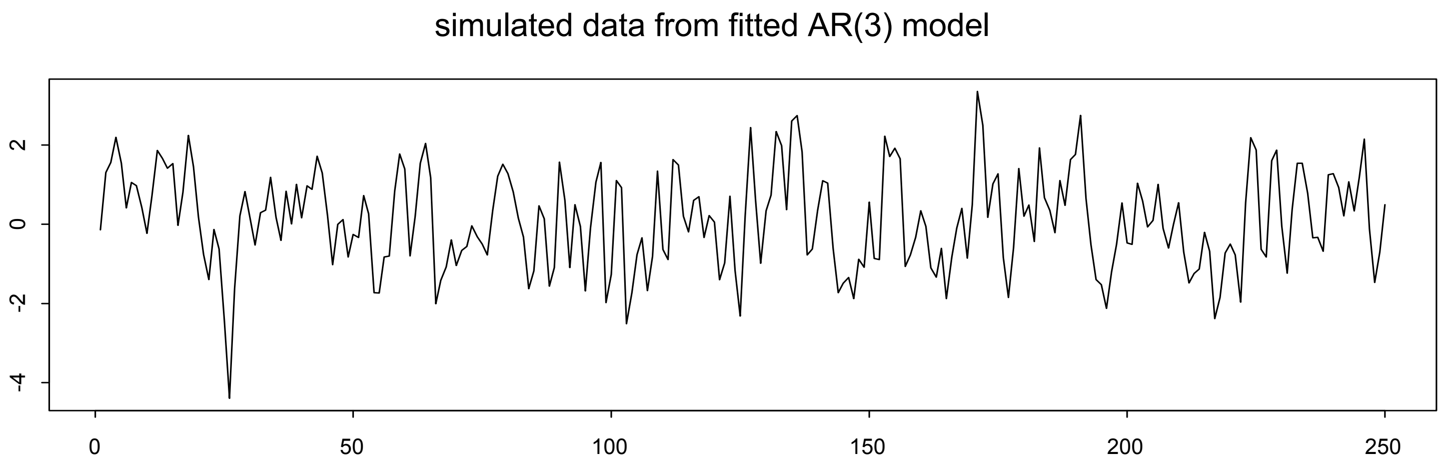




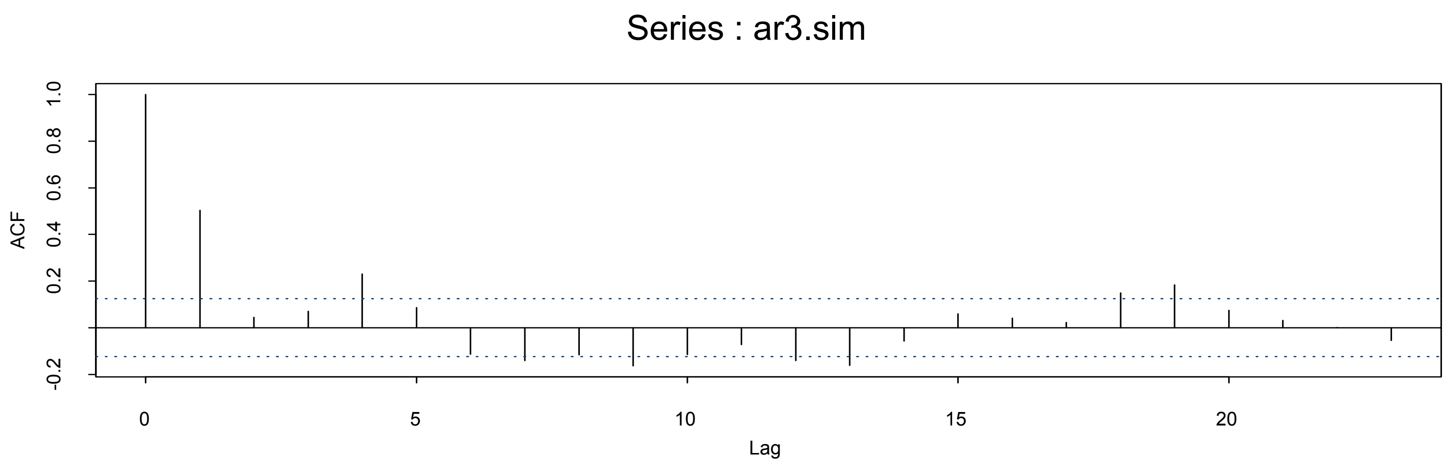
Simulation from Auxiliary Model

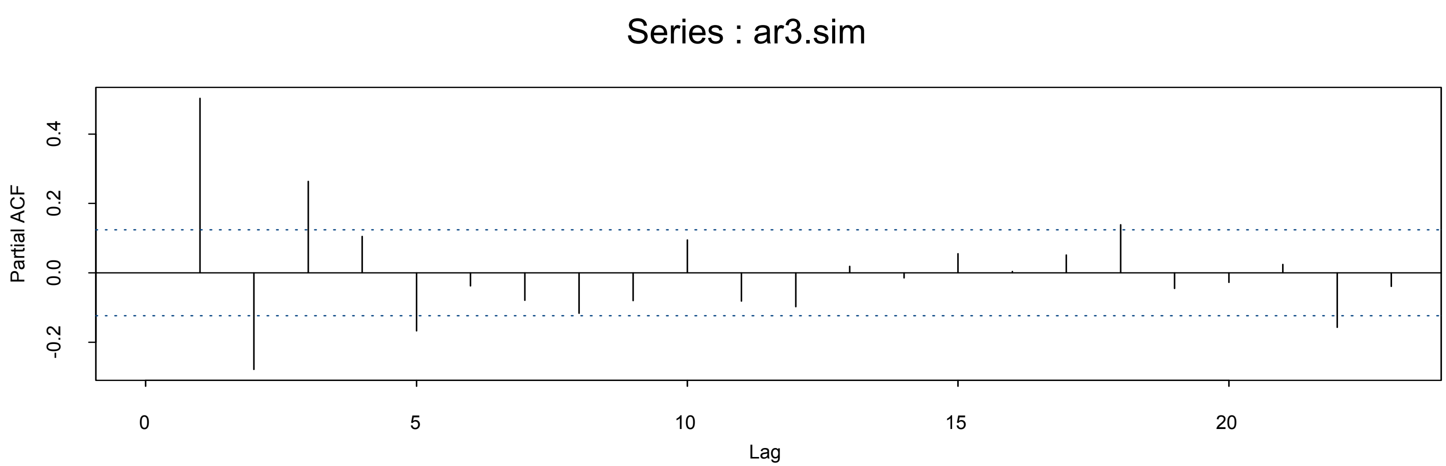
```
ar3.sim = simulate(ar3.fit)
```





Diagnostics from Simulated Auxiliary Model





EMM Fit of MA(1) Model

```
# create inputs to MA1.gensim
> set.seed(345)
> z = rnorm(10000)
> z.start = rnorm(100)
> MA1.aux = list(innov = z, innov.start = z.start)

# fit MA(1) model using EMM
> EMM.fit = EMM(ar3.fit,coef=c(-0.5,1),
+ control = EMM.control(n.burn=100,n.sim=10000),
+ gensim.fn="MA1.gensim2",gensim.language="SPLUS",
+ gensim.aux=MA1.aux)

> class(EMM.fit)
[1] "EMM"
```

EMM Fit of MA(1) Model

```
> EMM.fit
Call:
EMM(score = ar3.fit, coef = c(-0.5, 1), control =
EMM.control(n.burn = 100, n.sim = 10000), gensim.fn =
"MA1.gensim2",
gensim.language = "SPLUS", gensim.aux = MA1.aux)

Coefficients:
       Value     Std. Error      95% Conf. Int.
theta -0.7812    0.11832       -1.1729    -0.6298
sigma  0.9486    0.04586        0.8205     1.0170

Final optimization:
  Convergence: relative function convergence
  Iterations: 8
  Normalized objective at final iteration: 0.9392
  P-value on 3 df is 0.816
```

EMM Diagnostics

```
EMM Diagnostics

          Score          Std. Error       t-ratio
    mu 1.15746942    1.241852      0.932051340
 phi.1 0.03844991    1.267703      0.030330384
 phi.2 0.28548072    1.359517      0.209986938
 phi.3 0.17188357    1.197335      0.143555120
sigma2 0.01452084    1.545968      0.009392714
```

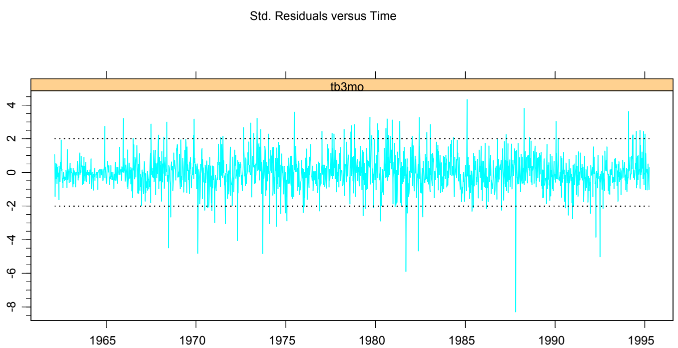
Fit SNP 200100 Model

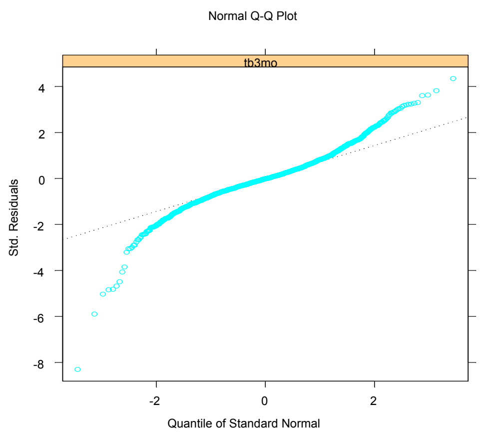
```
> fit.200100 = SNP(tb3mo,model=SNP.model(ar=2),n.drop=6)
> summary(fit.200100)

Model: Gaussian VAR

Conditional Mean Coefficients:
                mu     ar(1)     ar(2)
     coef   0.0006    1.0911   -0.0969
(std.err)   0.0036    0.0107    0.0109
 (t.stat)   0.1661  101.9655   -8.8810

Conditional Variance Coefficients:
             sigma
     coef   0.0974
(std.err)   0.0006
 (t.stat) 153.7107
```

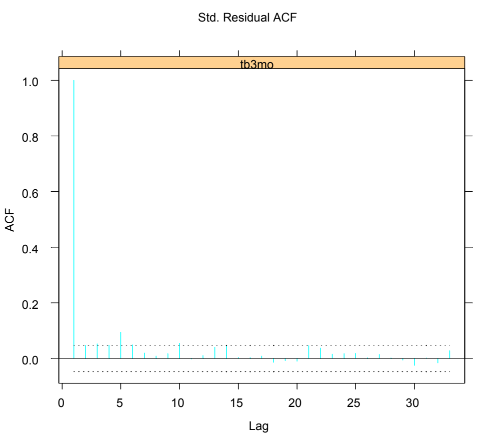
Fit SNP 204100 Model

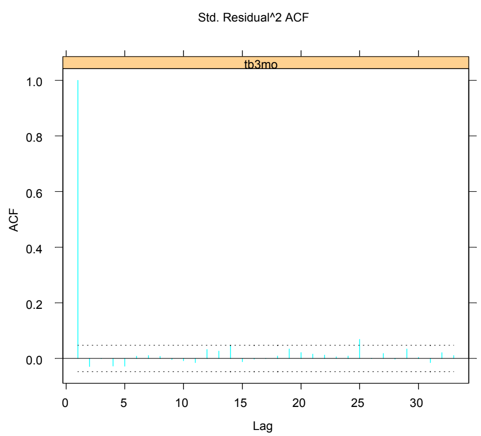
```
> fit.204100 = expand(fit.200100,arch=4)
> summary(fit.204100)

Model: Gaussian ARCH

Conditional Mean Coefficients:
               mu    ar(1)    ar(2)
     coef  0.0009   1.0189  -0.0215
(std.err)  0.0008   0.0188   0.0190
 (t.stat)  1.2491  54.3261  -1.1321


Conditional Variance Coefficients:
              s0 arch(1) arch(2) arch(3) arch(4)
     coef  0.0211  0.4324  0.1358  0.3126  0.2879
(std.err)  0.0007  0.0257  0.0191  0.0224  0.0231
 (t.stat) 28.5737 16.8110  7.1039 13.9848 12.4683
```

Diagnostics for SNP 204100

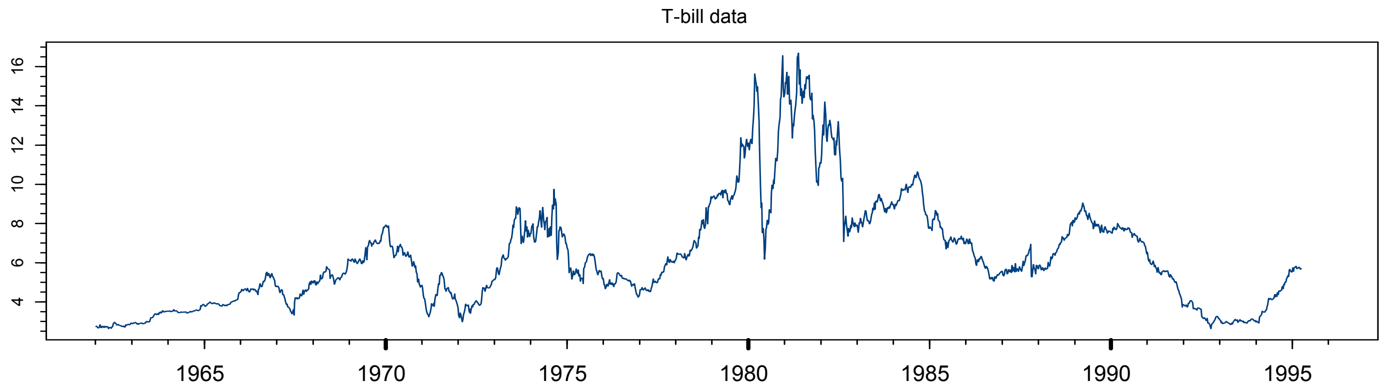


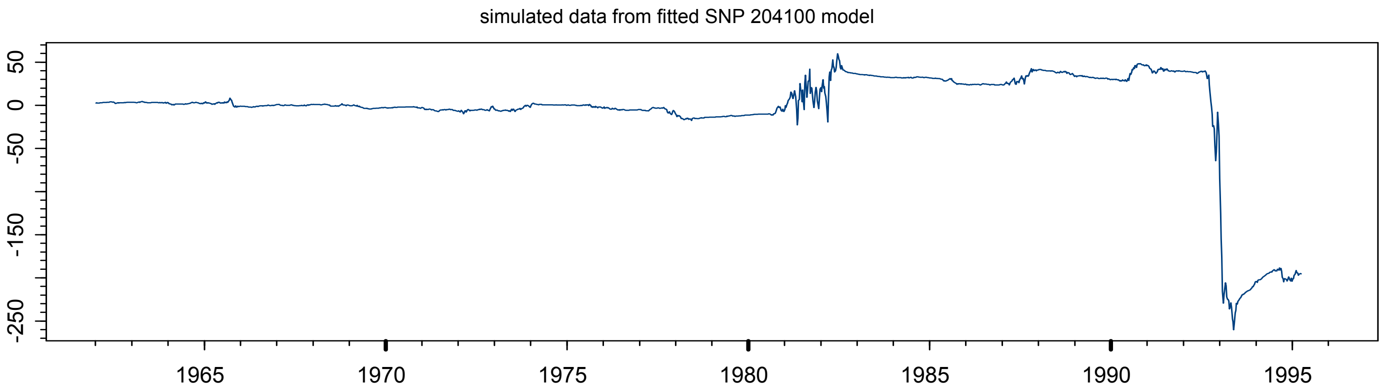






Simulation from SNP 204100





Fit SNP 211100 Model

```
> fit.211100 = expand(fit.200100,arch=1,garch=1)
> summary(fit.211100)

Model: Gaussian GARCH

Conditional Mean Coefficients:
                mu     ar(1)     ar(2)
     coef  -0.0014    1.0280   -0.0307
(std.err)   0.0009    0.0230    0.0230
 (t.stat)  -1.5642   44.7881   -1.3380


Conditional Variance Coefficients:
                s0   arch(1)  garch(1)
     coef   0.0023    0.2037    0.8383
(std.err)   0.0001    0.0085    0.0050
 (t.stat)  27.0769   23.9992  167.7730
```

Fit SNP 211140 Model

```
> fit.211140 = expand(fit.211100,zPoly=4)
> summary(fit.211140)

Model: Semiparametric GARCH

Hermite Polynomial Coefficients:
                z^0      z^1      z^2      z^3      z^4
     coef    1.0000   0.0754  -0.2025  -0.0065   0.0249
(std.err)             0.0242   0.0163   0.0051   0.0025
 (t.stat)             3.1098 -12.4038  -1.2911  10.1074

Conditional Mean Coefficients:
              mu    ar(1)    ar(2)
     coef -0.0065   1.0425  -0.0482
(std.err)  0.0016   0.0251   0.0252
 (t.stat) -4.0240  41.5080  -1.9124

Conditional Variance Coefficients:
              s0   arch(1)  garch(1)
     coef  0.0021   0.2362    0.8367
(std.err)  0.0001   0.0138    0.0069
 (t.stat) 15.2416  17.1264  121.0534
```

Fit SNP 211141 Model

```
> fit.211141 = expand(fit.211140,xPoly=1)
> fit.211141
```

```
Model: Nonlinear
Nonparametric

Hermite Polynomial
Coefficients:
          x^0     x^1
z^0  1.0000  0.3545
z^1  0.0961  0.0787
z^2 -0.1522  0.0291
z^3 -0.0075 -0.0086
z^4  0.0222  0.0007
```

```
Conditional Mean Coefficients:
       mu   ar(1)   ar(2)
 -0.0083 1.0382 -0.0469

Conditional Variance Coefficients:
      s0 arch(1) garch(1)
  0.0028  0.2034   0.8303

Information Criteria:
      BIC       HQ     AIC     logL
 -1.4444 -1.4593 -1.468 2553.258
```

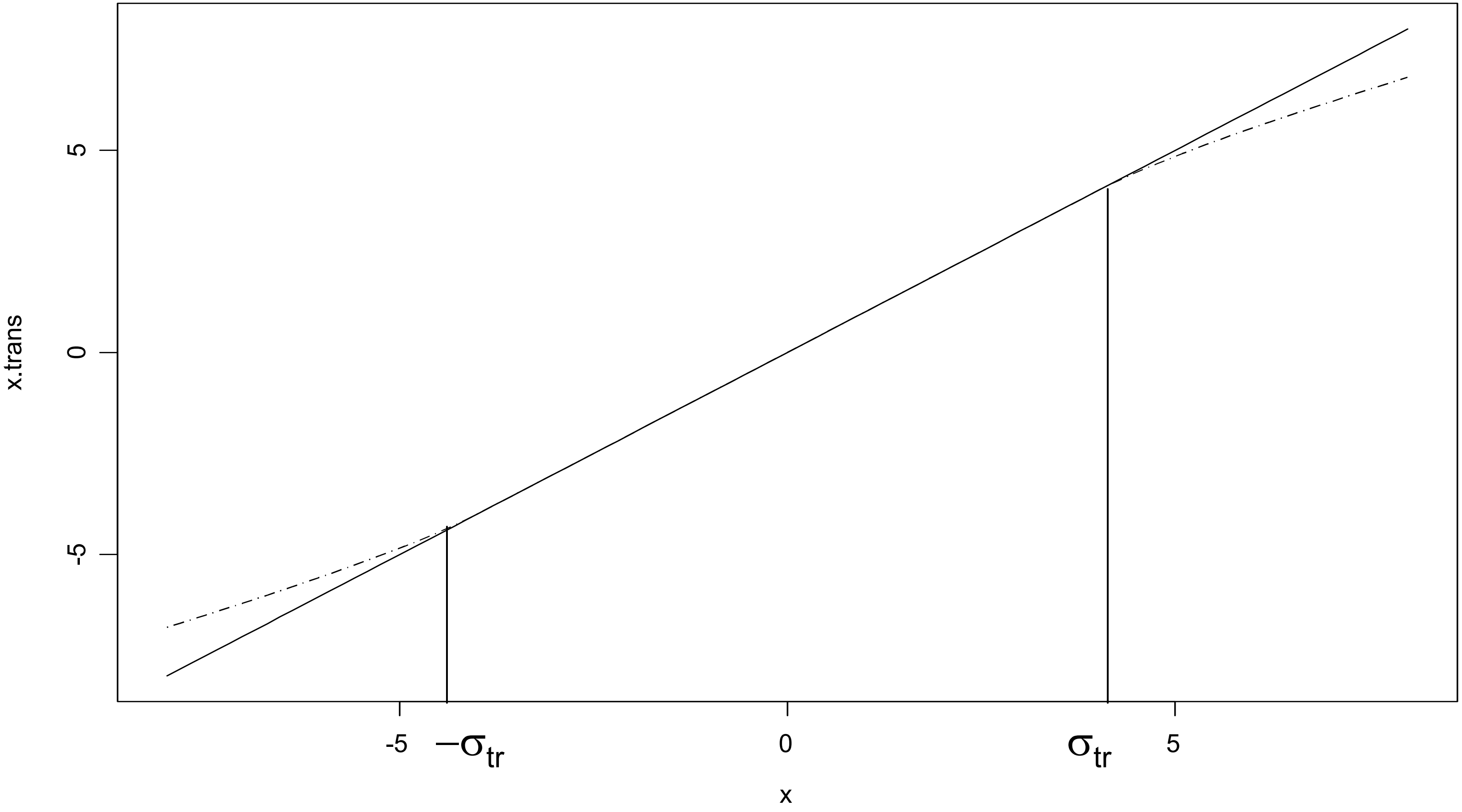
SNP Tuning Parameters

Parameter	SPLUS argument	Interpretation
L_u	`ar`	VAR lag
L_r	`arch`	ARCH lag
L_g	`garch`	GARCH lag
K_z	`zPoly`	Degree of z in P(z,x)
K_x	`xPoly`	Degree of x in P(z,x)
L_p	`lagP`	Lags in x part of Polynomial P(z,x)

Taxonomy of SNP Models

Parameter Setting	Auxilary model for y_t
$L_u=0$, $L_g=0$, $L_r=0$, $L_p\geq 0$, $K_z=0$, $K_x=0$	iid Gaussian
$\mathbf{L_u>0}$, $L_g=0$, $L_r=0$, $L_p\geq 0$, $K_z=0$, $K_x=0$	Gaussian VAR
$\mathbf{L_u>0}$, $L_g=0$, $L_r=0$, $L_p\geq 0$, $\mathbf{K_z>0}$, $K_x=0$	Semiparametric VAR
$L_u\geq 0$, $L_g=0$, $\mathbf{L_r>0}$, $L_p\geq 0$, $K_z=0$, $K_x=0$	Gaussian ARCH
$L_u\geq 0$, $L_g=0$, $\mathbf{L_r>0}$, $L_p\geq 0$, $\mathbf{K_z>0}$, $K_x=0$	Semiparametric ARCH
$L_u\geq 0$, $\mathbf{L_g>0}$, $L_r=0$, $L_p\geq 0$, $K_z=0$, $K_x=0$	Gaussian GARCH
$L_u\geq 0$, $\mathbf{L_g>0}$, $L_r=0$, $L_p\geq 0$, $\mathbf{K_z>0}$, $K_x=0$	Semiparametric GARCH
$L_u\geq 0$, $L_g\geq 0$, $L_r\geq 0$, $\mathbf{L_p>0}$, $\mathbf{K_z>0}$, $\mathbf{K_x>0}$	Nonlinear nonparametric

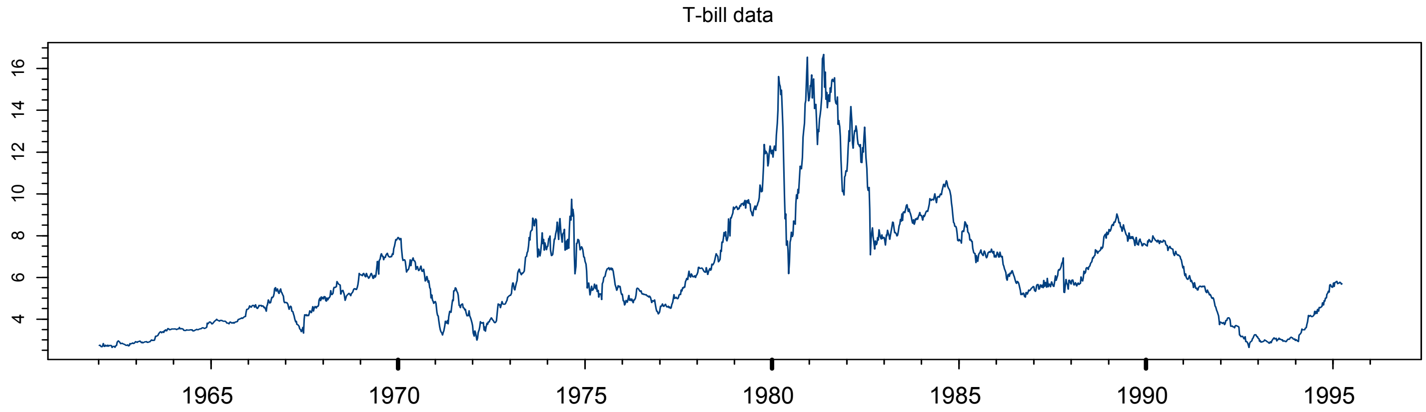
Log Spline Transformation

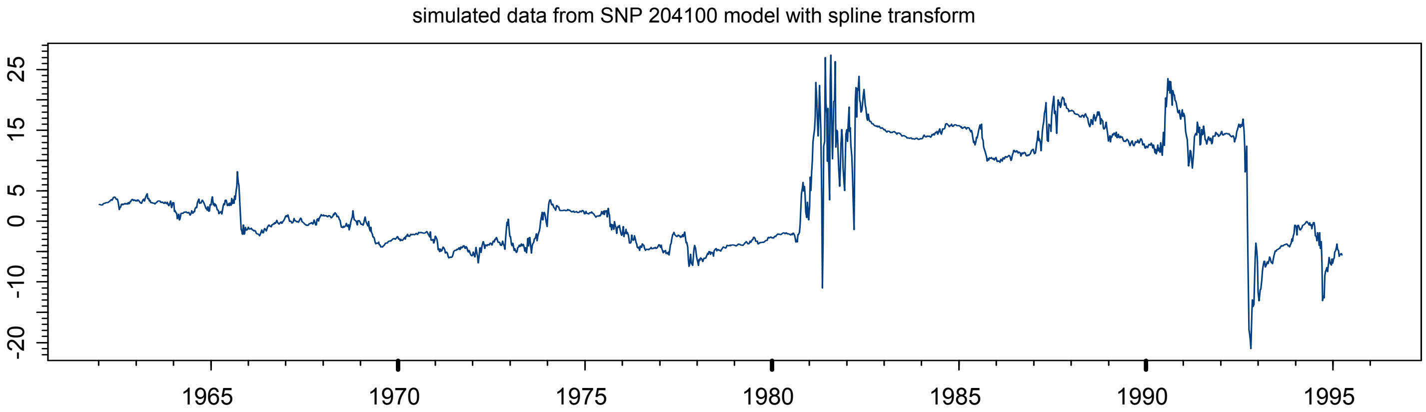


Fit SNP 204100 with Spline Transformation

```
> fit.204100.s =
+ SNP(tb3mo,model=SNP.model(ar=2,arch=4),n.drop=6,
+ control=SNP.control(xTransform="spline",inflection=4))
> fit.240100.s

Model: Gaussian ARCH

Conditional Mean Coefficients:
     mu   ar(1)    ar(2)
 0.0009 1.0189 -0.0215

Conditional Variance Coefficients:
     s0 arch(1) arch(2) arch(3) arch(4)
 0.0211  0.4324  0.1358  0.3126  0.2879

Information Criteria:
     BIC       HQ      AIC    logL
 -1.3418 -1.3498 -1.3544 2349.84
```

Simulation from SNP 204100 with Spline Transformation





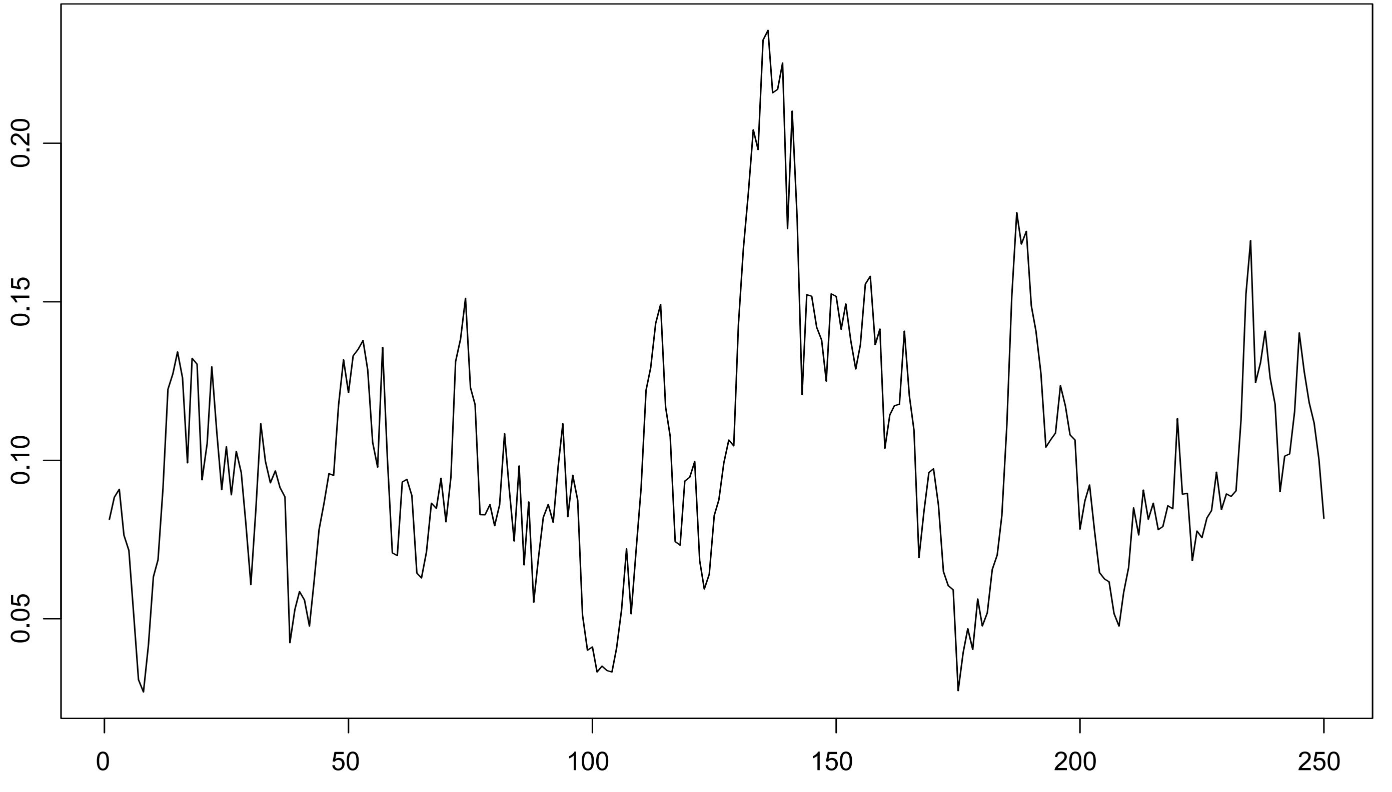
SNP: Automatic Model Selection

```
> fit.auto = SNP.auto(tb3mo,n.drop=6,
+ control=SNP.control(xTransform="spline",
+ inflection=4),
+ arMax=4,zPolyMax=8,xPolyMax=4,lagPMax=4)
Initializing using a Gaussian model ...
Expanding the order of VAR: 1234
Expanding toward GARCH model ...
Expanding the order of z-polynomial:
12345678
Expanding the order of x-polynomial: 1234
```

Simulation from CIR Model

```
# auxiliary parameters for simulator
> cir.aux = euler.pcode.aux(ndt = 100, seed=0,
+ lbound=0, ubound=100, X0=0.1,
+ drift.expr=expression(kappa*(theta-X)),
+ diffuse.expr=expression(sigma*sqrt(X)),
+ rho.names=c("kappa", "theta", "sigma"))

# model parameters
> rho.cir <- c(0.1,0.08,0.06)
> n.sim <- 250; n.burn <- 25; ndt <- 100

# Simulate using Euler’s method
> cir.sim <- euler1d.pcode.gensim(rho=rho.cir,
+ n.sim=250,n.burn=n.burn,aux=cir.aux)
```

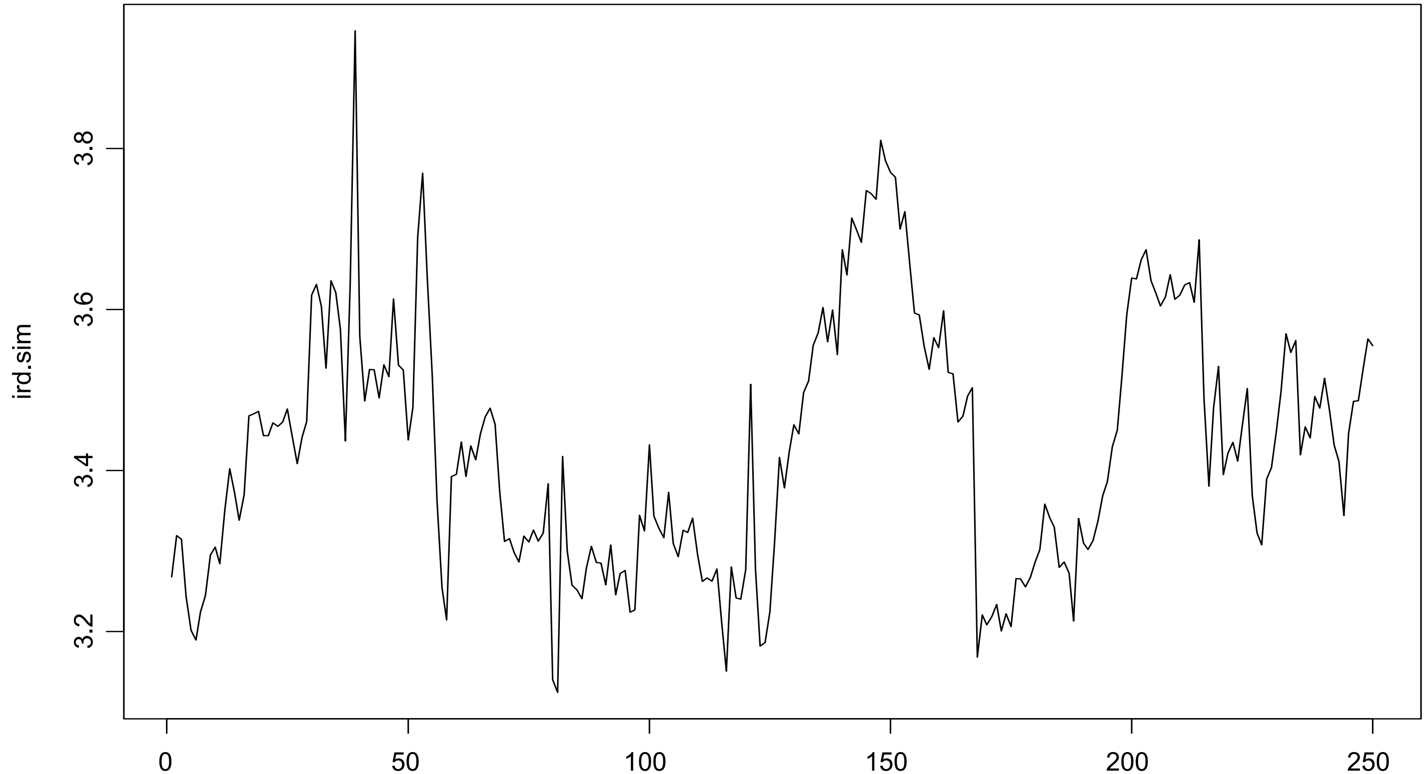
Simulation from CIR Model



Simulate 2 Factor Model

```
# parameter values
avv <- -.18; avs <- -.0088; as <- .019; ass <- -.0035; b1v <- .69;
b1vv <- 0; b1vs <- -.063; b2v <- 0; b2s <- .038; b2ss <- -.017

# IRD.gensim expects parameters packed into single vector
rho <- c(avv, avs, as, ass, b1v, b1vv, b1vs, b2v, b2s, b2ss)
n.sim <- 250; n.burn <- 150; ndt <- 14

# simulate data
z.sim <- rnorm((n.sim + n.burn)*ndt*2)
ird.sim <- IRD.gensim(rho = rho, n.sim = n.sim, n.burn = n.burn,
                      aux = IRD.aux(ndt = ndt, z = z.sim))
```

Simulated 2 Factor Model



Fit SNP Model to Simulated CIR data

```
> SNP.auto.cir = SNP.auto(cir.sim,arMax=8,n.drop=9,
+ control=SNP.control(xTransform="spline"))
Initializing using a Gaussian model ...
Expanding the order of VAR: 12345678
Expanding toward GARCH model ...
Expanding the order of z-polynomial: 12345678
Expanding the order of x-polynomial: 1234
> SNP.auto.cir
Model: Gaussian VAR

Conditional Mean Coefficients:
     mu  ar(1)
 0.0075 0.8886

Conditional Variance Coefficients:
  sigma
 0.4478
```

EMM Fit of CIR Model

```
> cir.nsim <- 50000
> set.seed(0)
> n.burn <- 25; ndt <- 100
> cir.z <- rnorm(ndt*(n.burn + cir.nsim))

> EMM.pcode.fit.cir <- EMM(SNP.auto.cir,
+ coef = c(0.1,0.1,0.1), est = c(1,1,1),
+ control = EMM.control(n.burn = n.burn, n.sim = cir.nsim),
+ gensim.fn = "euler1d.pcode.gensim",
+ gensim.language = "SPLUS",
+ gensim.aux = euler.pcode.aux(ndt = ndt, z = cir.z,
+                  lbound=0.0, ubound=100,
+                  drift.expr=expression(kappa*(theta-X)),
+                  diffuse.expr=expression(sigma*sqrt(X)),
+                  rho.names=c("kappa", "theta", "sigma")))
```

EMM Fit of CIR Model

```
> EMM.pcode.fit.cir

Coefficients:
        Value  Std. Error       95% Conf. Int.
kappa  0.10942    0.03296  0.07263    0.23203
theta  0.10353    0.01013  0.08597    0.12097
sigma  0.05426    0.00378  0.04728    0.06173

Final optimization:
  Convergence: absolute function convergence
  Iterations: 15
  Normalized objective at final iteration: 5.899e-007
```