This is a WinBUGS Codes for the artificial example in Chapter 9, Section 9.7.

Model: Two-level nonlinear structural equation model
Data Set Name: YO.dat
Sample Size: N=1555

Note: pi[g,j] is for omega(2g,j), lb and lw are for lambda2 and lambda_1, respectively.

```
model{
   for(g in 1:50){
       for(i in 1:N[g]){
           for(j in 1:9){
               y[kk[g]+i,j]~dnorm(u[kk[g]+i,j],psi[j])
               ephat[kk[g]+i,j]<-y[kk[g]+i,j]-u[kk[g]+i,j]
           }
          u[kk[g]+i,1]<- mu[1]+pi[g,1]+eta[g,i]
          u[kk[g]+i,2]<- mu[2]+lb[1]*pi[g,1]+lw[1]*eta[g,i]
          u[kk[g]+i,3]<- mu[3]+lb[2]*pi[g,1]+lw[2]*eta[g,i]
          u[kk[g]+i,4]<- mu[4]+pi[g,2]+xi[g,i,1]
          u[kk[g]+i,5]<- mu[5]+lb[3]*pi[g,2]+lw[3]*xi[g,i,1]
          u[kk[g]+i,6]<- mu[6]+lb[4]*pi[g,2]+lw[4]*xi[g,i,1]
          u[kk[g]+i,7]<- mu[7]+pi[g,3]+xi[g,i,2]
          u[kk[g]+i,8]<- mu[8]+lb[5]*pi[g,3]+lw[5]*xi[g,i,2]
          u[kk[g]+i,9]<- mu[9]+lb[6]*pi[g,3]+lw[6]*xi[g,i,2]
          xi[g,i,1:2]~dmnorm(ux[1:2],phi[1:2,1:2])      # ux=[0 0]^T  is fixed constant
          eta[g,i]~dnorm(nu[g,i], psd)
          nu[g,i]<- gam[1]*xi[g,i,1]+gam[2]*xi[g,i,2]+gam[3]*xi[g,i,1]*xi[g,i,2]
           dthat[g,i]<-eta[g,i]-nu[g,i]
       }# end of i
       pi[g,1:3]~ dmnorm(uu[1:3],phip[1:3,1:3])
    }# end of g

   uu[1]<- 0.0    uu[2]<- 0.0    uu[3]<- 0.0    ux[1]<- 0.0     ux[2]<- 0.0
   # priors on loadings and coefficients
   mu[1]~dnorm(4.248,4.0)        mu[2]~dnorm(4.668,4.0)        mu[3]~dnorm(4.56,4.0)
   mu[4]~dnorm(2.389,4.0)        mu[5]~dnorm(3.161,4.0)        mu[6]~dnorm(3.445,4.0)
   mu[7]~dnorm(0.526,4.0)        mu[8]~dnorm(0.375,4.0)        mu[9]~dnorm(0.596,4.0)
   var.bw[1]<-4.0*psi[2]         var.bw[2]<-4.0*psi[3]         var.bw[3]<-4.0*psi[5]
   var.bw[4]<-4.0*psi[6]         var.bw[5]<-4.0*psi[8]         var.bw[6]<-4.0*psi[9]
   lb[1]~dnorm(1.096,var.bw[1])   lb[2]~dnorm(0.861,var.bw[2])     lb[3]~dnorm(0.590,var.bw[3])
   lb[4]~dnorm(1.470,var.bw[4])   lb[5]~dnorm(0.787,var.bw[5])     lb[6]~dnorm(0.574,var.bw[6])
   lw[1]~dnorm(0.825,var.bw[1])   lw[2]~dnorm(0.813,var.bw[2])     lw[3]~dnorm(0.951,var.bw[3])
   lw[4]~dnorm(0.692,var.bw[4])   lw[5]~dnorm(0.986,var.bw[5])     lw[6]~dnorm(0.800,var.bw[6])
   var.gam<-4.0*psd
   gam[1]~dnorm(0.577,var.gam) gam[2]~dnorm(1.712,var.gam)  gam[3]~dnorm(-0.571,var.gam)
   # priors on precisions
   for(j in 1:9){psi[j]~dgamma(10.0,4.0)
                 ivpsi[j]<-1/psi[j]}
   psd~dgamma(10.0,4.0)
   ivpsd<-1/psd
   phi[1:2,1:2]~dwish(R0[1:2,1:2],5)
   phx[1:2,1:2]<-inverse(phi[1:2,1:2])
```

```
   phip[1:3,1:3]~dwish(R1[1:3,1:3],5)
   php[1:3,1:3]<-inverse(phip[1:3,1:3])
}# end of model
```

Data

```
list(N=c(28,27,25,28,33,26,18,26,17,24,26,24,24,30,23,24,29,27,34,18,20,14,27,28,28,
          26,43,32,43,43,41,47,45,41,25,36,32,36,44,36,32,37,36,27,38,34,39,40,37,37),
kk=c(0,28,55,80,108,141,167,185,211,228,252,278,302,326,356,379,403,432,459,493,511,
      531,545,572,600,628,654,697,729,772,815,856,903,948,989,1014,1050,1082,1118,1162,
      1198,1230,1267,1303,1330,1368,1402,1441,1481,1518),
R0=structure(.Data= c(1.940,0.775,0.775,0.600),  .Dim= c(2,2)),
R1=structure(.Data= c(13.6,-0.61,0.48,-0.61,0.24,0.06,0.48,0.06,0.22),  .Dim= c(3,3)),
y=structure(.Data= c(paste YO.dat here),  .Dim= c(1555,9)))
```

Three different initial values

```
list(lb=c(0.6,0.6,0.5,2.2,0.6,0.4), lw=c(0.3,0.3,0.3,0.3,0.3,0.3),
mu=c(3.0,3.5,3.3,1.0,2.0,2.2,0.2,0.0,0.2),
psi=c(0.3, 0.3, 0.3, 0.3, 0.3, 0.3,0.3,0.3,0.3), psd=0.6,  gam=c(0.2,1.0,-0.4),
phip=structure(.Data=c(0.7,-0.1,0.0,-0.1,0.2,0.0,0.0,0.0,0.18), .Dim=c(3,3)),
phi=structure(.Data=c(0.7, 0.4,0.4,0.7),  .Dim= c(2,2)))

list(lb=c(0.8,0.8,0.7,2.5,0.8,0.6), lw=c(0.7,0.7,0.7,0.7,0.7,0.7),
mu=c(4.0,4.0,4.0,2.0,3.0,3.0,0.5,0.4,0.6),
psi=c(0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5,0.5,0.5), psd=0.36,  gam=c(0.5,1.7,0.6),
phip=structure(.Data=c(0.5,0.1,-0.1,0.1,0.2,0.0,-0.1,0.0,0.5), .Dim=c(3,3)),
phi=structure(.Data=c(0.5, 0.1,0.1,0.5),  .Dim= c(2,2)))

list(lb=c(1.0,1.0,1.0,3.0,1.0,1.0), lw=c(1.0,1.0,1.0,1.0,1.0,1.0),
mu=c(4.8,4.8,4.8,3.5,4.0,4.2,0.8,0.8,0.8),
psi=c(0.8, 0.8, 0.8, 0.8, 0.8, 0.8,0.8,0.8,0.8), psd=0.9,  gam=c(0.8,1.2,0.0),
phip=structure(.Data=c(0.6,-0.2,0.2,-0.2,0.4,0.1,0.2,0.1,0.3), .Dim=c(3,3)),
phi=structure(.Data=c(0.9, 0.0,0.0,0.6),  .Dim= c(2,2)))
```