Online Appendix to accompany "Investigating multilevel mediation with fully or partially nested data"

Contents:

Section A: Scalar equations for the fully nested MSEM example (example 1)

This section of the online appendix details the scalar MSEM equations for the fully nested simulated example described in the text. TP_{ij} corresponds to the dependent variable team performance, CTC_{ij} to the mediator commitment to change, PC_{ij} to the mediator perceived charisma, and CPB_{ij} is the independent variable change promoting behavior. Corresponding to equations 6, 7, and 8 in the text:

$$
\begin{aligned}
TP_j &= \widetilde{TP}_j \\
CTC_{ij} &= \widetilde{CTC}_{ij} + \widetilde{CTC}_j \\
PC_{ij} &= \widetilde{PC}_{ij} + \widetilde{PC}_j \\
CPB_{ij} &= \widetilde{CPB}_{ij} + \widetilde{CPB}_j
\end{aligned}
$$

Between:

$$
\begin{aligned}
\widetilde{TP}_j &= b_0^{TP} + b_{1B}^{TP}\widetilde{CTC}_j + \zeta_j^{TP} \\
\widetilde{CTC}_j &= b_0^{CTC} + b_{1B}^{CTC}\widetilde{PC}_j + \zeta_j^{CTC} \\
\widetilde{PC}_j &= b_0^{PC} + b_{1B}^{PC}\widetilde{CPB}_j + \zeta_j^{PC} \\
\widetilde{CPB}_j &= b_0^{CPB} + \zeta_j^{CPB}
\end{aligned}
$$

Within:

$$
\begin{aligned}
\widetilde{CTC}_{ij} &= b_{1W}^{CTC}\widetilde{PC}_{ij} + \varepsilon_{ij}^{CTC} \\
\widetilde{PC}_{ij} &= b_{1W}^{PC}\widetilde{CPB}_{ij} + \varepsilon_{ij}^{PC} \\
\widetilde{CPB}_{ij} &= \varepsilon_{ij}^{CPB}
\end{aligned}
$$

where:

$$
\begin{bmatrix} \zeta_j^{TP} \\ \zeta_j^{CTC} \\ \zeta_j^{PC} \\ \zeta_j^{CPB} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \psi^{TP} & & & \\ 0 & \psi^{CTC} & & \\ 0 & 0 & \psi^{PC} & \\ 0 & 0 & 0 & \psi^{CPB} \end{bmatrix} \right)
$$

$$
\begin{bmatrix} \varepsilon_{ij}^{CTC} \\ \varepsilon_{ij}^{PC} \\ \varepsilon_{ij}^{CPB} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \theta_\varepsilon^{CTC} & & \\ 0 & \theta_\varepsilon^{PC} & \\ 0 & 0 & \theta_\varepsilon^{CPB} \end{bmatrix} \right)
$$

Section B: Scalar equations for the partially nested MSEM example (example 2)

Clustered arm:

$$TP_j = \widetilde{TP}^c_j$$
$$CTC_{ij} = \widetilde{CTC}^c_{ij} + \widetilde{CTC}^c_j$$
$$PC_{ij} = \widetilde{PC}^c_{ij} + \widetilde{PC}^c_j$$
$$CPB_{ij} = \widetilde{CPB}^c_{ij} + \widetilde{CPB}^c_j$$

Between:

$$\widetilde{TP}^c_j = b_0^{TPc} + b_{1B}^{TPc}\widetilde{CTC}^c_j + \zeta_j^{TPc}$$
$$\widetilde{CTC}^c_j = b_0^{CTCc} + b_{1B}^{CTCc}\widetilde{PC}^c_j + \zeta_j^{CTCc}$$
$$\widetilde{PC}^c_j = b_0^{PCc} + b_{1B}^{PCc}\widetilde{CPB}^c_j + \zeta_j^{PCc}$$
$$\widetilde{CPB}^c_j = b_0^{CPBc} + \zeta_j^{CPBc}$$

Within:

$$\widetilde{CTC}^c_{ij} = b_{1W}^{CTCc}\widetilde{CPB}^c_{ij} + b_{2W}^{CTCc}\widetilde{PC}^c_{ij} + \varepsilon_{ij}^{CTCc}$$
$$\widetilde{PC}^c_{ij} = b_{1W}^{PCc}\widetilde{CPB}^c_{ij} + \varepsilon_{ij}^{PCc}$$
$$\widetilde{CPB}^c_{ij} = \varepsilon_{ij}^{CPBc}$$

where:

$$\begin{bmatrix} \zeta_j^{TPc} \\ \zeta_j^{CTCc} \\ \zeta_j^{PCc} \\ \zeta_j^{CPBc} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \psi^{TPc} & & & \\ 0 & \psi^{CTCc} & & \\ 0 & 0 & \psi^{PCc} & \\ 0 & 0 & 0 & \psi^{CPBc} \end{bmatrix} \right)$$

$$\begin{bmatrix} \varepsilon_{ij}^{CTCc} \\ \varepsilon_{ij}^{PCc} \\ \varepsilon_{ij}^{CPBc} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \theta_\varepsilon^{CTCc} & & \\ 0 & \theta_\varepsilon^{PCc} & \\ 0 & 0 & \theta_\varepsilon^{CPBc} \end{bmatrix} \right)$$

Unclustered arm (each person is their own cluster):

$$TP_j = \widetilde{TP}^u_j$$
$$CTC_{ij} = \widetilde{CTC}^u_{ij} + \widetilde{CTC}^u_j$$
$$PC_{ij} = \widetilde{PC}^u_{ij} + \widetilde{PC}^u_j$$
$$CPB_{ij} = \widetilde{CPB}^u_{ij} + \widetilde{CPB}^u_j$$

$$\widetilde{TP}^u_j = b_0^{TPu} + b_{1B}^{TPu}\widetilde{CTC}^u_j + \zeta_j^{TPu}$$
$$\widetilde{CTC}^u_j = b_0^{CTCu} + b_{1B}^{CTCu}\widetilde{PC}^u_j + \zeta_j^{CTCu}$$
$$\widetilde{PC}^u_j = b_0^{PCu} + b_{1B}^{PCu}\widetilde{CPB}^u_j + \zeta_j^{PCu}$$
$$\widetilde{CPB}^u_j = b_0^{CPBu} + \zeta_j^{CPBu}$$

$$\widetilde{CTC}^u_{ij} = 0$$
$$\widetilde{PC}^u_{ij} = 0$$
$$\widetilde{CPB}^u_{ij} = 0$$

$$\begin{bmatrix} \zeta_j^{TPu} \\ \zeta_j^{CTCu} \\ \zeta_j^{PCu} \\ \zeta_j^{CPBu} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \psi^{TPu} & & & \\ 0 & \psi^{CTCu} & & \\ 0 & 0 & \psi^{PCu} & \\ 0 & 0 & 0 & \psi^{CPBu} \end{bmatrix} \right)$$

Section C: M*plus* fully nested syntax

```
DATA: FILE IS fullynest_seed100.dat; !call dataset
VARIABLE:
NAMES ARE TP PC CTC CPB CLUSTER; !name variables
USEVARIABLES ARE TP PC CTC CPB; !variables to be used in analysis
CLUSTER=CLUSTER; !identify clustering variable
BETWEEN ARE TP; !identify between-cluster (level-2) variables
ANALYSIS: TYPE IS TWOLEVEL;
MODEL:
%WITHIN% !within-cluster (level-1) model
PC CTC CPB; !estimate within-cluster variances
CTC ON PC (bw); !regress CTC on PC, call the slope "bw"
PC ON CPB (aw); !regress PC on CPB, call the slope "aw"
%BETWEEN% !between-group (level-2) model
CPB PC CTC TP; !estimate between-cluster variances
PC ON CPB (ab); !regress PC on CPB, call the slope "ab"
CTC ON PC (bb); !regress CTC on PC, call the slope "bb"
TP ON CTC (cb); !regress CTC on TP, call the slope "cb"
[CPB TP PC CTC]; !estimate variable means

MODEL CONSTRAINT:
NEW(indb_3 indb_2 indw_2 diff); !create indirect effect parameters
indb_3=ab*bb*cb; !between-cluster indirect effect 1
indb_2=ab*bb; !between-cluster indirect effect 2
indw_2=aw*bw; !within-cluster indirect effect
diff=indb_2-indw_2; !diff. of within- and between-cluster indirect effects

OUTPUT: TECH1 TECH3 SVALUES;
```

Section D: M*plus* fully nested output

```
SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                         142

Number of dependent variables                                    3
Number of independent variables                                  1
Number of continuous latent variables                            0

Observed dependent variables

  Continuous
   TP          PC          CTC

Observed independent variables
   CPB

Variables with special functions

  Cluster variable      CLUSTER

  Between variables
```

```
   TP


Estimator                                                      MLR
Information matrix                                        OBSERVED
Maximum number of iterations                                   100
Convergence criterion                                    0.100D-05
Maximum number of EM iterations                                500
Convergence criteria for the EM algorithm
  Loglikelihood change                                   0.100D-02
  Relative loglikelihood change                          0.100D-05
  Derivative                                             0.100D-03
Minimum variance                                         0.100D-03
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03
Optimization algorithm                                         EMA

Input data file(s)
  fullynest_seed100.dat
Input data format  FREE

SUMMARY OF DATA

     Number of clusters                        33

     Average cluster size                    4.303

     Estimated Intraclass Correlations for the Y Variables

           Intraclass          Intraclass          Intraclass
  Variable Correlation Variable Correlation Variable Correlation

     PC        0.588      CTC        0.203      CPB        0.510

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters                      16

Loglikelihood

          H0 Value                       -498.701
          H0 Scaling Correction Factor     0.9223
            for MLR
          H1 Value                       -494.147
          H1 Scaling Correction Factor     0.8396
            for MLR

Information Criteria

          Akaike (AIC)                   1029.401
          Bayesian (BIC)                 1076.695
          Sample-Size Adjusted BIC       1026.070
            (n* = (n + 2) / 24)
```

```
Chi-Square Test of Model Fit

          Value                              17.900*
          Degrees of Freedom                      4
          P-Value                            0.0013
          Scaling Correction Factor          0.5088
            for MLR

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                            0.156

CFI/TLI

          CFI                                 0.917
          TLI                                 0.814
Chi-Square Test of Model Fit for the Baseline Model

          Value                             177.445
          Degrees of Freedom                      9
          P-Value                            0.0000

SRMR (Standardized Root Mean Square Residual)

          Value for Within                    0.057
          Value for Between                   0.081

MODEL RESULTS
                                                      Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

Within Level

 CTC        ON
    PC                 0.362      0.148      2.444      0.015

 PC         ON
    CPB                0.375      0.041      9.241      0.000

 Variances
    CPB                0.707      0.079      9.000      0.000

 Residual Variances
    PC                 0.150      0.018      8.534      0.000
    CTC                0.649      0.081      8.009      0.000

Between Level

 PC         ON
    CPB                0.455      0.133      3.413      0.001

 CTC        ON
    PC                 0.656      0.151      4.344      0.000

 TP         ON
    CTC                0.602      0.259      2.326      0.020
```

```
 Means
    CPB                3.916       0.167     23.449       0.000

 Intercepts
    TP                 5.409       2.493      2.170       0.030
    PC                 3.321       0.555      5.988       0.000
    CTC                6.308       0.790      7.985       0.000

 Variances
    CPB                0.793       0.181      4.373       0.000

 Residual Variances
    TP                 0.249       0.068      3.649       0.000
    PC                 0.192       0.041      4.681       0.000
    CTC                0.008       0.024      0.312       0.755

 New/Additional Parameters
    INDB_3             0.180       0.076      2.368       0.018
    INDB_2             0.299       0.121      2.466       0.014
    INDW_2             0.136       0.057      2.382       0.017
    DIFF               0.163       0.138      1.178       0.239
```

Section E: M*plus* partially nested syntax

```
DATA: FILE IS bothnest_seed100.dat;
VARIANCES=NOCHECK;

VARIABLE: NAMES ARE  TP PC CTC CPB CLUSTER treat; !name variables
USEVARIABLES ARE  TP PC CTC CPB; !identify variables for analysis
CLUSTER IS cluster; !identify clustering variable
GROUPING IS treat (0=cont 1=txt); !identify grouping (study arm) variable
BETWEEN IS tp; !identify between-cluster (level-2) variables
ANALYSIS:  TYPE IS TWOLEVEL;

MODEL: !model for tx (nested) group
%WITHIN% !within-cluster (level-1) model for tx group
PC CTC CPB; !estimate within-cluster variances
CTC ON PC (bw); !regress CTC on PC, call the slope "bw"
PC ON CPB (aw); !regress PC on CPB, call the slope "aw"

%BETWEEN% !between-cluster (level-2) model for tx group
CPB PC CTC TP; !estimate between-cluster variances
PC ON CPB (ab); !regress PC on CPB, call the slope "ab"
CTC ON PC (bb); !regress CTC on PC, call the slope "bb"
TP ON CTC (cb); !regress TP on CTC, call the slope "cb"
[CPB TP PC CTC]; !estimate means

MODEL cont: !model for control (non-nested) group
%WITHIN% !within-cluster (level-1) model for control group
PC@0; CTC@0; CPB@0; !all variances set to 0
CTC ON PC@0; !regression of CTC on PC set to 0
PC ON CPB@0; !regression of PC on CPB set to 0

%BETWEEN% !between-cluster (level-2) model for control group
CPB PC CTC TP; !estimate between-cluster variances
```

```
PC ON CPB (a); !regress PC on CPB, call the slope "a"
CTC ON PC (b); !regress CTC on PC, call the slope "b"
TP ON CTC (c); !regress TP on CTC, call the slope "c"
[CPB TP PC CTC]; !estimate means

MODEL CONSTRAINT:
!create indirect effect variables
NEW(indb_3 indb_2 indw_2 diff inds_3 inds_2 diff3_arm diff2_arm);
indb_3=ab*bb*cb; !first between-cluster indirect effect for tx group
indb_2=ab*bb; !second between-cluster indirect effect for tx group
indw_2=aw*bw; !within-cluster indirect effect for tx group
diff=indb_2-indw_2; !diff. in within- and between-cluster
                    !indirect effects for tx group

inds_3=a*b*c; !first indirect effect for control group
inds_2=a*b; !second indirect effect for control group
diff3_arm=indb_3-inds_3; !diff. in first indirect effect
                         !across tx and control groups
diff2_arm=indw_2-inds_2; !diff. in second indirect effect
                         !across tx and control groups

OUTPUT: NOCHISQUARE TECH1 TECH3 SVALUES;
```

Section F: M*plus* partially nested output

```
SUMMARY OF ANALYSIS

Number of groups                                                 2
Number of observations
   Group CONT                                                  142
   Group TXT                                                   142
   Total sample size                                           284

Number of dependent variables                                    3
Number of independent variables                                  1
Number of continuous latent variables                            0

Observed dependent variables

  Continuous
   TP          PC          CTC

Observed independent variables
   CPB

Variables with special functions

  Grouping variable     TREAT
  Cluster variable      CLUSTER

  Between variables
   TP


Estimator                                                      MLR
```

```
Information matrix                                          OBSERVED
Maximum number of iterations                                     100
Convergence criterion                                      0.100D-05
Maximum number of EM iterations                                  500
Convergence criteria for the EM algorithm
  Loglikelihood change                                     0.100D-02
  Relative loglikelihood change                            0.100D-05
  Derivative                                               0.100D-03
Minimum variance                                           0.100D-03
Maximum number of steepest descent iterations                     20
Maximum number of iterations for H1                             2000
Convergence criterion for H1                               0.100D-03
Optimization algorithm                                           EMA

Input data file(s)
  bothnest_seed100.dat
Input data format  FREE

SUMMARY OF DATA

   Group CONT
     Number of clusters                        142

   Group TXT
     Number of clusters                         33

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters                       27

Loglikelihood

          H0 Value                       -1126.689
          H0 Scaling Correction Factor      0.9653
            for MLR

Information Criteria

          Akaike (AIC)                    2307.377
          Bayesian (BIC)                  2405.900
          Sample-Size Adjusted BIC        2320.282
            (n* = (n + 2) / 24)

MODEL RESULTS
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

Group CONT

Within Level

 CTC        ON
    PC                 0.000      0.000    999.000    999.000

 PC         ON
```

```
    CPB                0.000      0.000    999.000    999.000

 Variances
    CPB                0.000      0.000    999.000    999.000

 Residual Variances
    PC                 0.000      0.000    999.000    999.000
    CTC                0.000      0.000    999.000    999.000

Between Level

 PC         ON
    CPB                0.357      0.043      8.221      0.000

 CTC        ON
    PC                 0.295      0.100      2.938      0.003

 TP         ON
    CTC                0.185      0.056      3.322      0.001

 Means
    CPB                3.943      0.095     41.366      0.000

 Intercepts
    TP                 4.453      0.419     10.629      0.000
    PC                 3.656      0.174     20.995      0.000
    CTC                5.941      0.519     11.441      0.000

 Variances
    CPB                1.290      0.170      7.590      0.000

 Residual Variances
    TP                 0.315      0.040      7.884      0.000
    PC                 0.276      0.033      8.447      0.000
    CTC                0.727      0.075      9.733      0.000

Group TXT

Within Level

 CTC        ON
    PC                 0.362      0.148      2.444      0.015

 PC         ON
    CPB                0.375      0.041      9.241      0.000

 Variances
    CPB                0.707      0.079      9.000      0.000

 Residual Variances
    PC                 0.150      0.018      8.534      0.000
    CTC                0.649      0.081      8.009      0.000

Between Level

 PC         ON
    CPB                0.455      0.133      3.413      0.001
```

```
CTC        ON
   PC                 0.656      0.151      4.344      0.000

TP         ON
   CTC                0.602      0.259      2.326      0.020

Means
   CPB                3.916      0.167     23.449      0.000

Intercepts
   TP                 5.409      2.493      2.170      0.030
   PC                 3.321      0.555      5.988      0.000
   CTC                6.308      0.790      7.985      0.000

Variances
   CPB                0.793      0.181      4.373      0.000

Residual Variances
   TP                 0.249      0.068      3.649      0.000
   PC                 0.192      0.041      4.681      0.000
   CTC                0.008      0.024      0.312      0.755

New/Additional Parameters
   INDB_3             0.180      0.076      2.368      0.018
   INDB_2             0.299      0.121      2.466      0.014
   INDW_2             0.136      0.057      2.382      0.017
   DIFF               0.163      0.138      1.178      0.239
   INDS_3             0.019      0.009      2.222      0.026
   INDS_2             0.105      0.038      2.788      0.005
   DIFF3_AR           0.160      0.076      2.097      0.036
   DIFF2_AR           0.031      0.068      0.448      0.654
```

Section G: Monte Carlo CI R syntax

```
#example 1, between indirect effect (2 paths)
require(MASS) #load required package
a=.455 #assign estimated values to parameters
b=.656
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b) #put estimates into a vector
#create 2x2 acov matrix from tech3 output in Mplus
acov <- matrix(c(
0.17810755E-01, 0.38238370E-02,
0.38238370E-02, 0.22770649E-01),2,2)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
ieb <- mcmc[,1]*mcmc[,2] #define indirect effect
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(ieb,low) #find lower confidence limit
UL=quantile(ieb,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b,LL,UL)) #print the output
#make a histogram
hist(ieb,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect')

#example 1, within indirect effect (2 paths)
require(MASS) #load required package
a=.375 #assign estimated values to parameters
b=.362
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b) #put estimates into a vector
#create 2x2 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.16491521E-02, -0.18865290E-03,
-0.18865290E-03,  0.21896878E-01),2,2)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
iew <- mcmc[,1]*mcmc[,2] #define indirect effect
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(iew,low) #find lower confidence limit
UL=quantile(iew,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b,LL,UL)) #print the output
#make a histogram
hist(iew,breaks='FD',col='skyblue',
```

```
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect')
```

#example 1, difference of B and W indirect effects

```
require(MASS) #load required package
a=.455 #assign estimated values to parameters
b=.656
c=.375
d=.362
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b,c,d) #put estimates into a vector
#create 4x4 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.17810755E-01,  0.38238370E-02, -0.30266999E-02, -0.89393417E-04,
 0.38238370E-02,  0.22770649E-01,  0.10262729E-03,  0.68648195E-03,
-0.30266999E-02,  0.10262729E-03,  0.16491521E-02, -0.18865290E-03,
-0.89393417E-04,  0.68648195E-03, -0.18865290E-03,  0.21896878E-01
),4,4)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
#define indirect effect difference
iediff <- mcmc[,1]*mcmc[,2]-mcmc[,3]*mcmc[,4]
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(iediff,low) #find lower confidence limit
UL=quantile(iediff,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b-c*d,LL,UL)) #print the output
#make a histogram
hist(iediff,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect Difference')
```

#example 1, between indirect effect (3 paths)

```
require(MASS) #load required package
a=.455 #assign estimated values to parameters
b=.656
c=.602
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b,c) #put estimates into a vector
#create 3x3 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.17810755E-01,  0.38238370E-02, -0.85890777E-02,
 0.38238370E-02,  0.22770649E-01, -0.21358784E-01,
-0.85890777E-02, -0.21358784E-01,  0.66926164E-01),3,3)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
ieb <- mcmc[,1]*mcmc[,2]*mcmc[,3] #define indirect effect
low=(1-conf/100)/2
```

```
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(ieb,low) #find lower confidence limit
UL=quantile(ieb,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b*c,LL,UL)) #print the output
#make a histogram
hist(ieb,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect')
```

#example 2, between indirect effect (2 paths)

```
require(MASS) #load required package
a=.357 #assign estimated values to parameters
b=.295
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b) #put estimates into a vector
#create 2x2 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.188400E-02, -0.106188E-03,
-0.106188E-03,  0.100600E-01),2,2)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
ieb <- mcmc[,1]*mcmc[,2] #define indirect effect
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(ieb,low) #find lower confidence limit
UL=quantile(ieb,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b,LL,UL)) #print the output
#make a histogram
hist(ieb,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect')
```

#example 2, between indirect effect (3 paths)

```
require(MASS) #load required package
a=.357 #assign estimated values to parameters
b=.295
c=.185
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b,c) #put estimates into a vector
#create 3x3 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.188400E-02, -0.106188E-03, -0.447846E-04,
-0.106188E-03,  0.100600E-01, -0.418114E-03,
-0.447846E-04, -0.418114E-03,  0.310931E-02),3,3)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
```

```
ieb <- mcmc[,1]*mcmc[,2]*mcmc[,3] #define indirect effect
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(ieb,low) #find lower confidence limit
UL=quantile(ieb,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b*c,LL,UL)) #print the output
#make a histogram
hist(ieb,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect')
```

#example 2, difference of B indirect effects

```
require(MASS) #load required package
a=.455 #assign estimated values to parameters
b=.656
c=.602
d=.357
e=.295
f=.185
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b,c,d,e,f) #put estimates into a vector
#create 6x6 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.178107E-01,  0.382340E-02, -0.858833E-02, 0, 0, 0,
 0.382340E-02,  0.227697E-01, -0.213564E-01, 0, 0, 0,
-0.858833E-02, -0.213564E-01,  0.669208E-01, 0, 0, 0,
 0, 0, 0,  0.188400E-02, -0.106188E-03, -0.447846E-04,
 0, 0, 0, -0.106188E-03,  0.100600E-01, -0.418114E-03,
 0, 0, 0, -0.447846E-04, -0.418114E-03,  0.310931E-02),6,6)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
#define indirect effect difference
iediff <- mcmc[,1]*mcmc[,2]*mcmc[,3]-mcmc[,4]*mcmc[,5]*mcmc[,6]
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(iediff,low) #find lower confidence limit
UL=quantile(iediff,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b*c-d*e*f,LL,UL)) #print the output
#make a histogram
hist(iediff,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect Difference')
```

#example 2, difference of unclustered and W indirect effects

```
require(MASS) #load required package
a=.375 #assign estimated values to parameters
b=.362
```

```
c=.357
d=.295
rep=10000000 #CI to be based on ten million reps
conf=95      #95% CI
pest <- c(a,b,c,d) #put estimates into a vector
#create 4x4 acov matrix from tech3 output in Mplus
acov <- matrix(c(
 0.16491521E-02, -0.18865290E-03, 0, 0,
-0.18865290E-03,  0.21896878E-01, 0, 0,
 0, 0,  0.188400E-02, -0.106188E-03,
 0, 0, -0.106188E-03,  0.100600E-01),4,4)
#generate MVN parameter distribution
mcmc <- mvrnorm(rep,pest,acov,empirical=FALSE)
#define indirect effect difference
iediff <- mcmc[,1]*mcmc[,2]-mcmc[,3]*mcmc[,4]
low=(1-conf/100)/2
upp=((1-conf/100)/2)+(conf/100)
LL=quantile(iediff,low) #find lower confidence limit
UL=quantile(iediff,upp) #find upper confidence limit
LL4=format(LL,digits=4) #round to 4 places
UL4=format(UL,digits=4) #round to 4 places
print(c(a*b-c*d,LL,UL)) #print the output
#make a histogram
hist(iediff,breaks='FD',col='skyblue',
  xlab=paste(conf,'% Confidence Interval ','LL',LL4,'  UL',UL4),
  main='Distribution of Indirect Effect Difference')
```