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TITLE:
    Random intercept cross-lagged panel model (RI-CLPM)
    using the new hat approach of Asparouhov & Muthen (2023).
    Residual structural equation models.
    Structural Equation Modeling, 30, 1-31.
  https://www.statmodel.com/download/RSEM.pdf
    See also the Muthen (2003) M3 workshop slides 18 and on:
  https://www.statmodel.com/download/M3TeachingSlides.pdf
    The hat (^) approach refers to the residual for a
    regression y ON x or a factor indicator f BY y
DATA:
    FILE = mwi.dat;
VARIABLE:
    NAMES = id s1-s5 d1-d5;
    USEVAR = s1-s5 d1-d5;
    MISSING = all (-999);
ANALYSIS:
    ESTIMATOR = MLR;
    ! no need to use MODEL=NOCOV of the old approach
    ! because hat variables are uncorrelated with
    ! other variables by definition.

MODEL:
  ! specify random intercepts:
  is BY s1-s5@1;
  id BY d1-d5@1;
```

! autoregressions using hats for each outcome

! with the short-hand PON (pairwise ON):

s2^-s5^ PON s1^-s4^;

d2^-d5^ PON d1^-d4^;

! cross-lagged regressions using hats for each outcome

! with the short-hand PON (pairwise ON):

s2^-s5^ PON d1^-d4^;

d2^-d5^ PON s1^-s4^;

! residual covariances using pairwise WITH:

s1^-s5^ PWITH d1^-d5^;

```
TITLE:  multiple-group ri-clpm using the hat approach

DATA:
   FILE = riclpm_mg.dat;

VARIABLE:
   NAMES = y1-y5 x1-x5 group;
   GROUPING = GROUP (1=female 2=male);

MODEL:
   ! random intercepts (correlated by default):
   riy BY y1@1 y2@1 y3@1 y4@1 y5@1;
   rix BY x1@1 x2@1 x3@1 x4@1 x5@1;

   ! ARs using pair-wise ON:
   y2^-y5^ PON y1^-y4^;
   x2^-x5^ PON x1^-x4^;
   ! cross-lagged effects:
   y2^-y5^ PON x1^-x4^;
   x2^-x5^ PON y1^-y4^;
   ! covariance:
   y1^ WITH x1^;
   ! residual covariances using pair-wise WITH:
   y2^-y5^ WITH x2^-x5^;
```

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MODEL MALE:
   ! when outcome means are allowed different,
   ! factor means should be fixed at zero in
   ! both groups. This avoids the default of
   ! freeing factor means for all but the first group.
   [riy-rix@0];
```

```
TITLE:  multiple-indicators ri-clpm using the hat approach

DATA:
   FILE = riclpm_mi.dat;

VARIABLE:
          NAMES= y11-y13 y21-y23 y31-y33 y41-y43 y51-y53
        x11-x13 x21-x23 x31-x33 x41-x43 x51-x53;

MODEL:
   ! factors:
   fy1 BY y11-y13; fy2 BY y21-y23; fy3 BY y31-y33;
   fy4 BY y41-y43; fy5 BY y51-y53;
   fx1 BY x11-x13; fx2 BY x21-x23; fx3 BY x31-x33;
   fx4 BY x41-x43; fx5 BY x51-x53;
   ! random intercepts (correlated by default):
   riy BY fy1@1 fy2@1 fy3@1 fy4@1 fy5@1;
   rix BY fx1@1 fx2@1 fx3@1 fx4@1 fx5@1;
   fy1-fx5 WITH riy-rix@0;
   ! ARs using pair-wise ON:
   fy2^-fy5^ PON fy1^-fy4^;
   fx2^-fx5^ PON fx1^-fx4^;
   ! cross-lagged effects:
   fy2^-fy5^ PON fx1^-fx4^;
   fx2^-fx5^ PON fy1^-fy4^;
   ! covariance:
```

```
fy1^ WITH fx1^;

! residual covariances using pair-wise WITH:

fy2^-fy5^ PWITH fx2^-fx5^;
```

```
TITLE:  multiple-indicators, multiple-group ri-clpm using the hat approach

DATA:
   FILE = riclpm_mi_mg.dat;

VARIABLE:
   NAMES = y11-y13 y21-y23 y31-y33 y41-y43 y51-y53
        x11-x13 x21-x23 x31-x33 x41-x43 x51-x53 group;
   GROUPING = GROUP(1=female 2=male);

MODEL:
   ! factors:
   fy1 BY y11-y13; fy2 BY y21-y23; fy3 BY y31-y33;
   fy4 BY y41-y43; fy5 BY y51-y53;
   fx1 BY x11-x13; fx2 BY x21-x23; fx3 BY x31-x33;
   fx4 BY x41-x43; fx5 BY x51-x53;
   ! random intercepts (correlated by default):
   riy BY fy1@1 fy2@1 fy3@1 fy4@1 fy5@1;
   rix BY fx1@1 fx2@1 fx3@1 fx4@1 fx5@1;
   fy1-fx5 WITH riy-rix@0;
   ! ARs using pair-wise ON:
   fy2^-fy5^ PON fy1^-fy4^;
   fx2^-fx5^ PON fx1^-fx4^;
   ! cross-lagged effects:
   fy2^-fy5^ PON fx1^-fx4^;
   fx2^-fx5^ PON fy1^-fy4^;
```

```
  ! covariance:
  fy1^ WITH fx1^;
  ! residual covariances using pair-wise WITH:
  fy2^-fy5^ PWITH fx2^-fx5^;

MODEL MALE:

   ! when outcome means are allowed different,
   ! factor means should be fixed at zero in
   ! both groups. This avoids the default of
   ! freeing all but the first group factor means.
   [riy-rix@0]; [fy1-fx5@0];
```

Monte Carlo Inputs:

```
TITLE:  multiple-group ri-clpm using the hat approach

MONTECARLO:
        NAMES = y1-y5 x1-x5;
        NUMOBSERVATIONS= 500 500;
        NGROUPS = 2;
        NREPS = 1;
        SAVE = riclpm_mg.dat;

MODEL POPULATION:
   ! random intercepts (correlated by default):
   riy BY y1@1 y2@1 y3@1 y4@1 y5@1;
   rix BY x1@1 x2@1 x3@1 x4@1 x5@1;
   riy-rix*1;
   riy WITH rix*0.5;
   ! ARs using pair-wise ON:
   y2^-y5^ PON y1^-y4^*0.2;
   x2^-x5^ PON x1^-x4^*0.2;
   ! cross-lagged effects:
   y2^-y5^ PON x1^-x4^*.1;
   x2^-x5^ PON y1^-y4^*.1;
   ! residual variances:
   y1^*1; x1^*1;
   y2^-y5^*0.8; x2^-x5^*0.8;
```

```
  ! covariance:
  y1^ WITH x1^*0.2;
  ! residual covariances using pair-wise WITH:
  y2^-y5^ PWITH x2^-x5^*0.1;

MODEL POPULATION-g2:
  [y1-x5*0]; ! outcome means can be different
  ! when outcome means are allowed different,
  ! factor means should be fixed at zero in
  ! both groups. This avoids the default of
  ! freeing all but the first group factor means.
  [riy-rix@0];

MODEL:
  ! random intercepts (correlated by default):
  riy BY y1@1 y2@1 y3@1 y4@1 y5@1;
  rix BY x1@1 x2@1 x3@1 x4@1 x5@1;
  riy-rix*1;
  riy WITH rix*0.5;
  ! ARs using pair-wise ON:
  y2^-y5^ PON y1^-y4^*0.2;
  x2^-x5^ PON x1^-x4^*0.2;
  ! cross-lagged effects:
  y2^-y5^ PON x1^-x4^*.1;
  x2^-x5^ PON y1^-y4^*.1;
  ! residual variances:
```

```
  y1^*1; x1^*1;
  y2^-y5^*0.8; x2^-x5^*0.8;
  ! covariance:
  y1^ WITH x1^*0.2;
  ! residual covariances using pair-wise WITH:
  y2^-y5^ PWITH x2^-x5^*0.1;

MODEL G2:
  [y1-x5*0]; ! outcome means can be different
  ! when outcome means are allowed different,
  ! factor means should be fixed at zero in
  ! both groups. This avoids the default of
  ! freeing all but the first group factor means.
  [riy-rix@0];

OUTPUT:
        TECH9;
```

```
TITLE:  multiple-indicators ri-clpm using the hat approach

MONTECARLO:
        NAMES = y11-y13 y21-y23 y31-y33 y41-y43 y51-y53
       x11-x13 x21-x23 x31-x33 x41-x43 x51-x53;
        NOBSERVATIONS = 500;

        NREPS = 1;
        SAVE = riclpm_mi.dat;

MODEL POPULATION:
  ! factors:
  fy1 BY y11@1 y12-y13*1; fy2 BY y21@1 y22-y23*1; fy3 BY y31@1 y32-y33*1;
  fy4 BY y41@1 y42-y43*1; fy5 BY y51@1 y52-y53*1;
  fx1 BY x11@1 x12-x13*1; fx2 BY x21@1 x22-x23*1; fx3 BY x31@1 x32-x33*1;
  fx4 BY x41@1 x42-x43*1; fx5 BY x51@1 x52-x53*1;
  fy1-fx5*0.5;
  y11-x53*1;
  ! random intercepts (correlated by default):
  riy BY fy1@1 fy2@1 fy3@1 fy4@1 fy5@1;
  rix BY fx1@1 fx2@1 fx3@1 fx4@1 fx5@1;
  riy-rix*0.5;
  riy WITH rix*0.2;
  fy1-fx5 WITH riy-rix@0;
  ! ARs using pair-wise ON:
  fy2^-fy5^ PON fy1^-fy4^*0.2;
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  fx2^-fx5^ PON fx1^-fx4^*0.2;
  ! cross-lagged effects:
  fy2^-fy5^ PON fx1^-fx4^*.1;
  fx2^-fx5^ PON fy1^-fy4^*.1;
  ! residual variances:
  fy1^*1; fx1^*1;
  fy2^-fy5^*0.8; fx2^-fx5^*0.8;
  ! covariance:
  fy1^ WITH fx1^*0.2;
  ! residual covariances using pair-wise WITH:
  fy2^-fy5^ PWITH fx2^-fx5^*0.1;

MODEL:
  ! factors:
  fy1 by y11@1 y12-y13*1; fy2 BY y21@1 y22-y23*1; fy3 BY y31@1 y32-y33*1;
  fy4 by y41@1 y42-y43*1; fy5 BY y51@1 y52-y53*1;
  fx1 by x11@1 x12-x13*1; fx2 BY x21@1 x22-x23*1; fx3 BY x31@1 x32-x33*1;
  fx4 by x41@1 x42-x43*1; fx5 BY x51@1 x52-x53*1;
  fy1-fx5*0.5;
  y11-x53*1;
  ! random intercepts (correlated by default):
  riy BY fy1@1 fy2@1 fy3@1 fy4@1 fy5@1;
  rix BY fx1@1 fx2@1 fx3@1 fx4@1 fx5@1;
  riy-rix*0.5;
  riy WITH rix*0.2;
  fy1-fx5 WITH riy-rix@0;
```

```
  ! ARs using pair-wise ON:
  fy2^-fy5^ PON fy1^-fy4^*0.2;
  fx2^-fx5^ PON fx1^-fx4^*0.2;
  ! cross-lagged effects:
  fy2^-fy5^ PON fx1^-fx4^*.1;
  fx2^-fx5^ PON fy1^-fy4^*.1;
  ! residual variances:
  fy1^*1; fx1^*1;
  fy2^-fy5^*0.8; fx2^-fx5^*0.8;
  ! covariance:
  fy1^ WITH fx1^*0.2;
  ! residual covariances using pair-wise WITH:
  fy2^-fy5^ PWITH fx2^-fx5^*0.1;

OUTPUT:
        TECH9;
```

```
TITLE:  multiple-indicators, multiple-group ri-clpm using the hat approach

MONTECARLO:
   NAMES = y11-y13 y21-y23 y31-y33 y41-y43 y51-y53
         x11-x13 x21-x23 x31-x33 x41-x43 x51-x53;
   NOBSERVATIONS = 500 500;
   NGROUPS = 2;

   NREPS= 1;
   SAVE = riclpm_mi_mg.dat;

MODEL POPULATION:
   ! factors:
   fy1 BY y11@1 y12-y13*1; fy2 BY y21@1 y22-y23*1; fy3 BY y31@1 y32-y33*1;
   fy4 BY y41@1 y42-y43*1; fy5 BY y51@1 y52-y53*1;
   fx1 BY x11@1 x12-x13*1; fx2 BY x21@1 x22-x23*1; fx3 BY x31@1 x32-x33*1;
   fx4 BY x41@1 x42-x43*1; fx5 BY x51@1 x52-x53*1;
   fy1-fx5*0.5;
   y11-x53*1;
   ! random intercepts (correlated by default):
   riy BY fy1@1 fy2@1 fy3@1 fy4@1 fy5@1;
   rix BY fx1@1 fx2@1 fx3@1 fx4@1 fx5@1;
   riy-rix*0.5;
   riy WITH rix*0.2;
   fy1-fx5 WITH riy-rix@0;
   ! ARs using pair-wise ON:
```

```
  fy2^-fy5^ PON fy1^-fy4^*0.2;
  fx2^-fx5^ PON fx1^-fx4^*0.2;
  ! cross-lagged effects:
  fy2^-fy5^ PON fx1^-fx4^*.1;
  fx2^-fx5^ PON fy1^-fy4^*.1;
  ! residual variances:
  fy1^*1; fx1^*1;
  fy2^-fy5^*0.8; fx2^-fx5^*0.8;
  ! covariance:
  fy1^ WITH fx1^*0.2;
  ! residual covariances using pair-wise WITH:
  fy2^-fy5^ PWITH fx2^-fx5^*0.1;

MODEL POPULATION-g2:
  [y11-x53*0]; ! outcome means can be different
   ! when outcome means are allowed different,
   ! factor means should be fixed at zero in
   ! both groups. This avoids the default of
   ! freeing all but the first group factor means.
   [riy-rix@0]; [fy1-fx5@0];

MODEL:
  ! factors:
  fy1 BY y11@1 y12-y13*1; fy2 BY y21@1 y22-y23*1; fy3 BY y31@1 y32-y33*1;
  fy4 BY y41@1 y42-y43*1; fy5 BY y51@1 y52-y53*1;
  fx1 BY x11@1 x12-x13*1; fx2 BY x21@1 x22-x23*1; fx3 BY x31@1 x32-x33*1;
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```
  fx4 BY x41@1 x42-x43*1; fx5 BY x51@1 x52-x53*1;
  fy1-fx5*0.5;
  y11-x53*1;
  ! random intercepts (correlated by default):
  riy by fy1@1 fy2@1 fy3@1 fy4@1 fy5@1;
  rix by fx1@1 fx2@1 fx3@1 fx4@1 fx5@1;
  riy-rix*0.5;
  riy WITH rix*0.2;
  fy1-fx5 WITH riy-rix@0;
  ! ARs using pair-wise ON:
  fy2^-fy5^ PON fy1^-fy4^*0.2;
  fx2^-fx5^ PON fx1^-fx4^*0.2;
  ! cross-lagged effects:
  fy2^-fy5^ PON fx1^-fx4^*.1;
  fx2^-fx5^ PON fy1^-fy4^*.1;
  ! residual variances:
  fy1^*1; fx1^*1;
  fy2^-fy5^*0.8; fx2^-fx5^*0.8;
  ! covariance:
  fy1^ WITH fx1^*0.2;
  ! residual covariances using pair-wise WITH:
  fy2^-fy5^ PWITH fx2^-fx5^*0.1;

MODEL g2:
  [y11-x53*0]; ! outcome means can be different
    ! when outcome means are allowed different,
```

```
    ! factor means should be fixed at zero in
    ! both groups. This avoids the default of
    ! freeing all but the first group factor means.
    [riy-rix@0]; [fy1-fx5@0];
```

OUTPUT:

```
    TECH9;
```