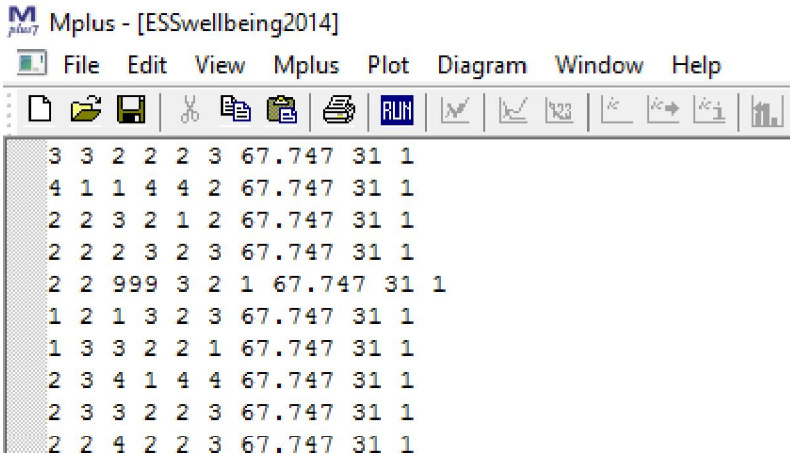
Example 1 – Emotional wellbeing

Preparing the data for analysis in Mplus:

- Download the dataset from http://www.europeansocialsurvey.org
- Select the relevant variables
- Match the individual data to the country-level data (using the countryID)
- Recode all responses to numerical values
- Give numerical values to missing values (e.g. 999)
- Save dataset as a .dat file without columnnames

Screenshot of my dataset in Mplus. The order of the variables is: fltdpr wrhpp enjlf fltsd fltanx fltpcfl IL CPI cntryID



The prepared dataset is available upon request by email (S.Jak@uva.nl)

- ALL INPUT FILES FOR EXAMPLE 1

Step 1 (obtaining intraclass correlations and fitting a null-model on the between-level):

Syntax to obtain intraclass correlations of the items:

```
DATA:
  FILE IS ESSwellbeing.dat;

VARIABLE:
  NAMES ARE       fltdpr wrhpp enjlf
                  fltsd fltanx fltpcfl
                  IL
                  CPI
                  cntryID;

  USEVARIABLES ARE
                  wrhpp enjlf fltpcfl
                  fltdpr fltsd fltanx ;

  MISSING ARE     fltdpr wrhpp enjlf fltsd fltanx fltpcfl (999);
  CLUSTER IS      cntryID;

ANALYSIS: TYPE IS twolevel basic;
```

Syntax to fit a null-model on the between level:

```
DATA:
  FILE IS ESSwellbeing.dat;

VARIABLE:
  NAMES ARE       fltdpr wrhpp enjlf
                  fltsd fltanx fltpcfl
                  IL
                  CPI
                  cntryID;

  USEVARIABLES ARE
                  wrhpp enjlf fltpcfl
                  fltdpr fltsd fltanx ;

  MISSING ARE     fltdpr wrhpp enjlf fltsd fltanx fltpcfl (999);
  CLUSTER IS      cntryID;

ANALYSIS: TYPE IS twolevel;

MODEL:
                  %WITHIN%
                  wrhpp with enjlf-fltanx;
                  enjlf with fltpcfl-fltanx;
                  fltpcfl with fltdpr-fltanx;
                  fltdpr with fltsd fltanx;
                  fltsd with fltanx;

                  %BETWEEN%
                  wrhpp-fltanx@0;
```

Step 2 (a measurement model within and a saturated model between):

All syntax except '`MODEL`' is identical to Step 1

```
MODEL:
                    %WITHIN%
                    posWB by wrhpp* enjlf fltpcfl;
                    posWB@1;

                    negWB by fltdpr* fltsd fltanx;
                    negWB@1;

                    %BETWEEN%
                    wrhpp with enjlf-fltanx;
                    enjlf with fltpcfl-fltanx;
                    fltpcfl with fltdpr-fltanx;
                    fltdpr with fltsd fltanx;
                    fltsd with fltanx;
```

Step 3a (strong factorial invariance model):

(all syntax except '`MODEL`' is identical to Step 1)

```
MODEL:
            %WITHIN%
            posWB by wrhpp* enjlf fltpcfl (1-3);
            posWB@1;

            negWB by fltdpr* fltsd fltanx (4-6);
            negWB@1;

            %BETWEEN%
            cposWB by wrhpp* enjlf fltpcfl (1-3);
            cposWB;

            cnegWB by fltdpr* fltsd fltanx (4-6);
            cnegWB;

            wrhpp-fltanx@0;
```

Step 3b (cluster bias model):

(all syntax except '`MODEL`' is identical to Step 1)

```
MODEL:
            %WITHIN%
            posWB by wrhpp* enjlf fltpcfl (1-3);
            posWB@1;

            negWB by fltdpr* fltsd fltanx (4-6);
            negWB@1;

            %BETWEEN%
            cposWB by wrhpp* enjlf fltpcfl (1-3);
            cposWB;

            cnegWB by fltdpr* fltsd fltanx (4-6);
            cnegWB;

            wrhpp-fltanx;
```

Step 4 (adding observed between-level variables to the model):

```
DATA:
  FILE IS ESSwellbeing.dat;
VARIABLE:
  NAMES ARE       fltdpr wrhpp enjlf
                  fltsd fltanx fltpcfl
                  IL
                  CPI
                  cntryID;

  USEVARIABLES ARE
                  wrhpp enjlf fltpcfl
                  fltdpr fltsd fltanx
                  IL CPI ;

  MISSING ARE
                  fltdpr wrhpp enjlf
                  fltsd fltanx fltpcfl
                  IL CPI (999);

  CLUSTER IS      cntryID;

  BETWEEN is      IL CPI;


ANALYSIS: TYPE IS twolevel;

MODEL:
            %WITHIN%
            posWB by wrhpp* enjlf fltpcfl (1-3);
            posWB@1;

            negWB by fltdpr* fltsd fltanx (4-6);
            negWB@1;


            %BETWEEN%
            cposWB by wrhpp* enjlf fltpcfl (1-3);
            cposWB;

            cnegWB by fltdpr* fltsd fltanx (4-6);
            cnegWB;

            cnegWB with IL CPI;
            cposWB with IL CPI;
            IL with CPI;

            enjlf on CPI; ! direct effect of CPI on Enjoy Life

OUTPUT:     stdyx;
```

- ANNOTATED OUTPUT FOR EXAMPLE 1

Fit statistics of Step 1 (Chi-square statistic of the null-model)

```
MODEL FIT INFORMATION

Number of Free Parameters                       27

Loglikelihood

          H0 Value                       -325996.327
          H0 Scaling Correction Factor        29.9977
            for MLR
          H1 Value                       -320072.111

Information Criteria

          Akaike (AIC)                    652046.653
          Bayesian (BIC)                  652287.161
          Sample-Size Adjusted BIC        652201.354
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                           11848.430*
          Degrees of Freedom                 21
          P-Value                            0.0000
          Scaling Correction Factor          Undefined
            for MLR
```

Significant chi-square indicates significant country-level variance

Intraclass correlations of Step 1 (proportions of indicator variance at the country-level)

Estimated Intraclass Correlations for the Y Variables

Variable	Intraclass Correlation	Variable	Intraclass Correlation	Variable	Intraclass Correlation
WRHPP	0.041	ENJLF	0.068	FLTPCFL	0.035
FLTDPR	0.067	FLTSD	0.089	FLTANX	0.122

ICCs range from .035 to .122

Fit statistics of Step 2 (measurement model at within-level)

```
THE MODEL ESTIMATION TERMINATED NORMALLY


MODEL FIT INFORMATION

Number of Free Parameters                       40

Loglikelihood

          H0 Value                       -321348.184
          H0 Scaling Correction Factor      8.4951
            for MLR
          H1 Value                       -320072.111
          H1 Scaling Correction Factor      7.8032
            for MLR

Information Criteria

          Akaike (AIC)                    642776.368
          Bayesian (BIC)                  643132.676
          Sample-Size Adjusted BIC        643005.555
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                             587.562*
          Degrees of Freedom                      8
          P-Value                           0.0000
          Scaling Correction Factor         4.3436
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.036

CFI/TLI

          CFI                                0.973
          TLI                                0.898
```

$\chi^2_{(8)} = 587.562$, $p < .05$, RMSEA = .036, CFI = .97

Standardized parameter estimates of Step 2 (measurement model at within-level)

STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
POSWB BY				
WRHPP	0.777	0.010	78.896	0.000
ENJLF	0.756	0.010	73.629	0.000
FLTPCFL	0.621	0.011	55.228	0.000
NEGWB BY				
FLTDPR	0.740	0.008	88.112	0.000
FLTSD	0.754	0.008	94.088	0.000
FLTANX	0.627	0.015	40.834	0.000
NEGWB WITH				
POSWB	-0.694	0.012	-58.237	0.000
Variances				
POSWB	1.000	0.000	999.000	999.000
NEGWB	1.000	0.000	999.000	999.000
Residual Variances				
WRHPP	0.397	0.015	25.940	0.000
ENJLF	0.428	0.016	27.584	0.000
FLTPCFL	0.615	0.014	44.079	0.000
FLTDPR	0.453	0.012	36.420	0.000
FLTSD	0.432	0.012	35.808	0.000
FLTANX	0.607	0.019	31.531	0.000

Factor loadings (λ_w)

Factor covariance (φ_w)

Factor variances (φ_w)

Residual variances (θ_w)

Fit statistics of Step 3a (strong factorial invariance)

```
THE MODEL ESTIMATION TERMINATED NORMALLY


MODEL FIT INFORMATION

Number of Free Parameters                       22

Loglikelihood

          H0 Value                       -324170.192
          H0 Scaling Correction Factor      25.1474
            for MLR
          H1 Value                       -320072.111

Information Criteria

          Akaike (AIC)                    648384.383
          Bayesian (BIC)                  648580.352
          Sample-Size Adjusted BIC        648510.436
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                             8196.160*
          Degrees of Freedom                      26
          P-Value                           0.0000
          Scaling Correction Factor        Undefined
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.076

CFI/TLI

          CFI                                0.618
          TLI                                0.559
```

$\chi^2_{(26)} = 8196.16$, $p < .05$, RMSEA = .076, CFI = .62

Fit statistics of Step 3b (accounting for country-bias by freeing residual variance at the country-level)

```
THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       28

Loglikelihood

          H0 Value                       -321361.991
          H0 Scaling Correction Factor        11.7680
            for MLR
          H1 Value                       -320072.111
          H1 Scaling Correction Factor         7.8032
            for MLR

Information Criteria

          Akaike (AIC)                    642779.982
          Bayesian (BIC)                  643029.397
          Sample-Size Adjusted BIC        642940.413
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                           1145.311*
          Degrees of Freedom                    20
          P-Value                           0.0000
          Scaling Correction Factor          2.2525
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.032

CFI/TLI

          CFI                                0.947
          TLI                                0.921
```

$\chi^2_{(20)} = 1145.3$, $p < .05$, RMSEA = .031, CFI = .95

Parameter estimates of Step 3b (unstandardized)

MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
Within Level					
POSWB BY					
WRHPP	0.626	0.013	47.612	0.000	Factor loadings (λ_w)
ENJLF	0.632	0.011	55.332	0.000	
FLTPCFL	0.507	0.012	43.851	0.000	
NEGWB BY					
FLTDPR	0.510	0.013	39.830	0.000	
FLTSD	0.517	0.015	34.586	0.000	
FLTANX	0.444	0.017	25.969	0.000	
NEGWB WITH					
POSWB	-0.694	0.012	-58.233	0.000	Factor covariance (φ_w)
Variances					
POSWB	1.000	0.000	999.000	999.000	Factor variances (φ_w)
NEGWB	1.000	0.000	999.000	999.000	
Residual Variances					
WRHPP	0.258	0.010	26.483	0.000	Residual variances (θ_w)
ENJLF	0.299	0.015	19.981	0.000	
FLTPCFL	0.411	0.014	28.778	0.000	
FLTDPR	0.216	0.011	20.150	0.000	
FLTSD	0.203	0.007	28.228	0.000	
FLTANX	0.304	0.016	19.300	0.000	
Between Level					
CPOSWB BY					
WRHPP	0.626	0.013	47.612	0.000	Factor loadings (λ_b)
ENJLF	0.632	0.011	55.332	0.000	
FLTPCFL	0.507	0.012	43.851	0.000	
CNEGWB BY					
FLTDPR	0.510	0.013	39.830	0.000	
FLTSD	0.517	0.015	34.586	0.000	
FLTANX	0.444	0.017	25.969	0.000	
CNEGWB WITH					
CPOSWB	-0.080	0.020	-4.098	0.000	Factor covariance (φ_b)
Intercepts					
WRHPP	2.889	0.031	93.143	0.000	Intercepts (α_b)
ENJLF	2.860	0.042	68.071	0.000	
FLTPCFL	2.794	0.029	96.094	0.000	
FLTDPR	1.526	0.034	44.322	0.000	
FLTSD	1.638	0.040	41.045	0.000	
FLTANX	1.666	0.049	33.987	0.000	
Variances					
CPOSWB	0.062	0.015	4.015	0.000	Factor variances (φ_b)
CNEGWB	0.137	0.034	4.082	0.000	
Residual Variances					
WRHPP	0.006	0.002	2.460	0.014	Residual variances (θ_b)
ENJLF	0.014	0.005	2.991	0.003	
FLTPCFL	0.014	0.004	3.887	0.000	
FLTDPR	0.004	0.003	1.337	0.181	
FLTSD	0.004	0.004	1.099	0.272	
FLTANX	0.039	0.010	3.854	0.000	

Calculating the ICC of the common factors using the factor variances:

ICC = φ_b / (φ_b + φ_w)

Positive wellbeing : .062/ (.062 + 1) = .058

Negative wellbeing : .137/ (.137 + 1) = .120

Calculating the proportion of country-bias per item:

Proportion of country-level bias in country-level variance:

$\theta_b / (\lambda_b^2 \phi_b + \theta_b)$

For Item 2: $.014 / (.632^2 * .062 + .014) = .361$
For Item 3: $.014 / (.507^2 * .062 + .014) = .468$
For Item 6: $.039 / (.444^2 * .137 + .039) = .591$

Proportion of country-level bias in total variance:

$\theta_b / (\lambda_b^2 \phi_b + \theta_b + \lambda_w^2 \phi_w + \theta_w)$.

For Item 2: $.014 / (.632^2 * .062 + .014 + .632^2 + .299) = .019$
For Item 3: $.014 / (.507^2 * .062 + .014 + .507^2 + .411) = .020$
For Item 6: $.039 / (.444^2 * .137 + .039 + .444^2 + .304) = .068$

Parameter estimates of Step 3b. (standardized)

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
POSWB BY				
WRHPP	0.777	0.010	78.674	0.000
ENJLF	0.756	0.010	73.763	0.000
FLTPCFL	0.621	0.011	55.249	0.000
NEGWB BY				
FLTDPR	0.740	0.008	88.110	0.000
FLTSD	0.754	0.008	94.320	0.000
FLTANX	0.627	0.015	40.842	0.000
NEGWB WITH				
POSWB	-0.694	0.012	-58.233	0.000
Variances				
POSWB	1.000	0.000	999.000	999.000
NEGWB	1.000	0.000	999.000	999.000
Residual Variances				
WRHPP	0.397	0.015	25.877	0.000
ENJLF	0.428	0.016	27.609	0.000
FLTPCFL	0.615	0.014	44.122	0.000
FLTDPR	0.453	0.012	36.479	0.000
FLTSD	0.432	0.012	35.841	0.000
FLTANX	0.607	0.019	31.532	0.000
Between Level				
CPOSWB BY				
WRHPP	0.894	0.037	24.405	0.000
ENJLF	0.801	0.072	11.086	0.000
FLTPCFL	0.727	0.066	11.037	0.000
CNEGWB BY				
FLTDPR	0.949	0.033	29.050	0.000
FLTSD	0.949	0.047	20.287	0.000
FLTANX	0.640	0.081	7.873	0.000
CNEGWB WITH				
CPOSWB	-0.871	0.067	-12.957	0.000
Intercepts				
WRHPP	16.564	2.014	8.223	0.000
ENJLF	14.570	1.108	13.153	0.000
FLTPCFL	16.079	1.327	12.117	0.000
FLTDPR	7.670	0.915	8.382	0.000
FLTSD	8.123	0.820	9.907	0.000
FLTANX	6.487	0.450	14.430	0.000
Variances				
CPOSWB	1.000	0.000	999.000	999.000
CNEGWB	1.000	0.000	999.000	999.000
Residual Variances				
WRHPP	0.201	0.065	3.069	0.002
ENJLF	0.358	0.116	3.090	0.002
FLTPCFL	0.472	0.096	4.928	0.000
FLTDPR	0.100	0.062	1.619	0.105
FLTSD	0.100	0.089	1.122	0.262
FLTANX	0.591	0.104	5.688	0.000

Factor loadings (λ_w)

Factor correlation (φ_w)

Factor variances (φ_w)

Residual variances (θ_w)

Factor loadings (λ_b)

Factor correlation (φ_b)

Intercepts (α_b)

Factor variances (φ_b)

Residual variances (θ_b)

Fit statistics of Step 4 (Adding observed variables)

```
THE MODEL ESTIMATION TERMINATED NORMALLY

     WARNING:  THE RESIDUAL COVARIANCE MATRIX (THETA) IS NOT POSITIVE DEFINITE.
     THIS COULD INDICATE A NEGATIVE VARIANCE/RESIDUAL VARIANCE FOR AN OBSERVED
     VARIABLE, A CORRELATION GREATER OR EQUAL TO ONE BETWEEN TWO OBSERVED
     VARIABLES, OR A LINEAR DEPENDENCY AMONG MORE THAN TWO OBSERVED VARIABLES.
     CHECK THE RESULTS SECTION FOR MORE INFORMATION.


MODEL FIT INFORMATION

Number of Free Parameters                       37

Loglikelihood

          H0 Value                       -321571.591
          H0 Scaling Correction Factor         9.1453
            for MLR
          H1 Value                       -320275.414
          H1 Scaling Correction Factor         6.0132
            for MLR

Information Criteria

          Akaike (AIC)                    643217.181
          Bayesian (BIC)                  643546.819
          Sample-Size Adjusted BIC        643429.232
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                           1383.132*
          Degrees of Freedom                    28
          P-Value                           0.0000
          Scaling Correction Factor         1.8743
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.030

CFI/TLI

          CFI                                0.952
          TLI                                0.926
```

Warning appears because the country-level residual variance of the item FLTSD is negative. As it is not significant from zero this can just be interpreted as absence of cluster bias in this item.

$\chi^2_{(28)} = 1383.1$, $p < .05$, RMSEA = .030, CFI = .95

Parameter estimates of Step 4 (unstandardized)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
Within Level					
POSWB BY					
WRHPP	0.626	0.013	47.625	0.000	Factor loadings (λ_w)
ENJLF	0.632	0.011	55.305	0.000	
FLTPCFL	0.507	0.012	43.860	0.000	
NEGWB BY					
FLTDPR	0.510	0.013	39.771	0.000	
FLTSD	0.518	0.015	34.638	0.000	
FLTANX	0.444	0.017	25.988	0.000	
NEGWB WITH					
POSWB	-0.694	0.012	-58.211	0.000	Factor covariance (φ_w)
Variances					
POSWB	1.000	0.000	999.000	999.000	Factor variances (φ_w)
NEGWB	1.000	0.000	999.000	999.000	
Residual Variances					
WRHPP	0.258	0.010	26.479	0.000	Residual variances (θ_w)
ENJLF	0.299	0.015	19.985	0.000	
FLTPCFL	0.411	0.014	28.775	0.000	
FLTDPR	0.216	0.011	20.138	0.000	
FLTSD	0.203	0.007	28.289	0.000	
FLTANX	0.304	0.016	19.302	0.000	
Between Level					
CPOSWB BY					
WRHPP	0.626	0.013	47.625	0.000	Factor loadings (λ_b)
ENJLF	0.632	0.011	55.305	0.000	
FLTPCFL	0.507	0.012	43.860	0.000	
CNEGWB BY					
FLTDPR	0.510	0.013	39.771	0.000	
FLTSD	0.518	0.015	34.638	0.000	
FLTANX	0.444	0.017	25.988	0.000	
CNEGWB WITH					Covariances between common factors and contextual variables
INDLIB	-2.806	0.729	-3.848	0.000	
CPI	-7.272	1.577	-4.611	0.000	
CPOSWB	-0.085	0.020	-4.364	0.000	
CPOSWB WITH					
INDLIB	1.801	0.574	3.141	0.002	
CPI	3.572	0.827	4.320	0.000	
INDLIB WITH					
CPI	110.019	39.264	2.802	0.005	
Means					Means of contextual variables
INDLIB	74.544	2.857	26.094	0.000	
CPI	62.414	3.553	17.566	0.000	
Intercepts					Intercepts (α_b)
WRHPP	2.889	0.031	93.124	0.000	
ENJLF	2.859	0.042	68.048	0.000	
FLTPCFL	2.794	0.029	96.027	0.000	
FLTDPR	1.526	0.034	44.339	0.000	
FLTSD	1.638	0.040	41.059	0.000	
FLTANX	1.666	0.049	33.988	0.000	
Variances					Variances of common factors and contextual variables
INDLIB	220.361	73.938	2.980	0.003	
CPI	365.968	71.229	5.138	0.000	
CPOSWB	0.061	0.015	4.087	0.000	
CNEGWB	0.173	0.044	3.909	0.000	
Residual Variances					Residual variances (θ_b)
WRHPP	0.006	0.003	2.282	0.023	
ENJLF	0.015	0.005	3.221	0.001	
FLTPCFL	0.013	0.004	3.612	0.000	
FLTDPR	0.008	0.005	1.611	0.107	
FLTSD	0.000	0.003	-0.090	0.928	
FLTANX	0.034	0.009	3.844	0.000	

Parameter estimates of Step 4 (standardized)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
POSWB BY				
WRHPP	0.777	0.010	78.681	0.000
ENJLF	0.756	0.010	73.769	0.000
FLTPCFL	0.621	0.011	55.243	0.000
NEGWB BY				
FLTDPR	0.739	0.008	87.692	0.000
FLTSD	0.754	0.008	94.948	0.000
FLTANX	0.627	0.015	40.882	0.000
NEGWB WITH				
POSWB	-0.694	0.012	-58.211	0.000
Variances				
POSWB	1.000	0.000	999.000	999.000
NEGWB	1.000	0.000	999.000	999.000
Residual Variances				
WRHPP	0.397	0.015	25.879	0.000
ENJLF	0.428	0.016	27.614	0.000
FLTPCFL	0.615	0.014	44.115	0.000
FLTDPR	0.453	0.012	36.346	0.000
FLTSD	0.432	0.012	36.037	0.000
FLTANX	0.607	0.019	31.564	0.000
Between Level				
CPOSWB BY				
WRHPP	0.893	0.040	22.501	0.000
ENJLF	0.790	0.070	11.209	0.000
FLTPCFL	0.734	0.068	10.750	0.000
CNEGWB BY				
FLTDPR	0.918	0.036	25.353	0.000
FLTSD	1.002	0.027	36.785	0.000
FLTANX	0.706	0.080	8.831	0.000
CNEGWB WITH				
INDLIB	-0.455	0.110	-4.139	0.000
CPI	-0.914	0.033	-27.517	0.000
CPOSWB	-0.830	0.097	-8.598	0.000
CPOSWB WITH				
INDLIB	0.490	0.107	4.602	0.000
CPI	0.755	0.094	8.072	0.000
INDLIB WITH				
CPI	0.387	0.116	3.329	0.001
Means				
INDLIB	5.022	0.983	5.107	0.000
CPI	3.263	0.415	7.865	0.000
Intercepts				
WRHPP	16.651	2.020	8.241	0.000
ENJLF	14.451	1.084	13.325	0.000
FLTPCFL	16.338	1.360	12.014	0.000
FLTDPR	6.605	0.910	7.254	0.000
FLTSD	7.630	0.851	8.964	0.000
FLTANX	6.372	0.418	15.228	0.000
Variances				
INDLIB	1.000	0.000	999.000	999.000
CPI	1.000	0.000	999.000	999.000
CPOSWB	1.000	0.000	999.000	999.000
CNEGWB	1.000	0.000	999.000	999.000
Residual Variances				
WRHPP	0.202	0.071	2.854	0.004
ENJLF	0.376	0.111	3.379	0.001
FLTPCFL	0.461	0.100	4.601	0.000
FLTDPR	0.157	0.066	2.367	0.018
FLTSD	-0.005	999.000	999.000	999.000
FLTANX	0.501	0.113	4.438	0.000

Factor loadings (λ_w)

Factor correlation (φ_w)

Factor variances (φ_w)

Residual variances (θ_w)

Factor loadings (λ_b)

Correlations between common factors and contextual variables

Means of contextual variables

Intercepts (α_b)

Variances of common factors and contextual variables

Residual variances (θ_b)

Country-level parameter estimates of Step 4 with the item ‘Enjoy Life’ regressed on CPI (unstandardized)

Between Level				
CPOSWB BY				
WRHPP	0.626	0.013	47.680	0.000
ENJLF	0.632	0.011	55.229	0.000
FLTPCFL	0.507	0.012	43.824	0.000
CNEGWB BY				
FLTDPR	0.510	0.013	39.770	0.000
FLTSD	0.518	0.015	34.639	0.000
FLTANX	0.444	0.017	25.988	0.000
ENJLF ON				
CPI	0.004	0.001	3.370	0.001
CNEGWB WITH				
INDLIB	-2.802	0.728	-3.850	0.000
CPI	-7.267	1.579	-4.601	0.000
CPOSWB	-0.075	0.017	-4.307	0.000
CPOSWB WITH				
INDLIB	1.613	0.514	3.137	0.002
CPI	3.064	0.726	4.219	0.000
INDLIB WITH				
CPI	109.877	39.189	2.804	0.005
Means				
INDLIB	74.548	2.856	26.098	0.000
CPI	62.414	3.553	17.566	0.000
Intercepts				
WRHPP	2.889	0.031	93.153	0.000
ENJLF	2.634	0.075	35.352	0.000
FLTPCFL	2.794	0.029	96.023	0.000
FLTDPR	1.526	0.034	44.339	0.000
FLTSD	1.638	0.040	41.059	0.000
FLTANX	1.666	0.049	33.989	0.000
Variances				
INDLIB	220.374	73.951	2.980	0.003
CPI	365.965	71.230	5.138	0.000
CPOSWB	0.053	0.013	4.152	0.000
CNEGWB	0.173	0.045	3.867	0.000
Residual Variances				
WRHPP	0.005	0.002	2.344	0.019
ENJLF	0.011	0.003	3.301	0.001
FLTPCFL	0.013	0.004	3.631	0.000
FLTDPR	0.008	0.005	1.577	0.115
FLTSD	0.000	0.003	-0.079	0.937
FLTANX	0.034	0.009	3.773	0.000

Direct effect of CPI on ENJLF (b)

Country-level parameter estimates of Step 4 with the item 'Enjoy Life' regressed on CPI (standardized)

Between Level

CPOSWB BY				
WRHPP	0.892	0.041	22.019	0.000
ENJLF	0.648	0.073	8.824	0.000
FLTPCFL	0.711	0.071	9.961	0.000
CNEGWB BY				
FLTDPR	0.918	0.037	24.971	0.000
FLTSD	1.002	0.028	35.701	0.000
FLTANX	0.706	0.082	8.658	0.000
ENJLF ON				
CPI	0.306	0.077	3.959	0.000
CNEGWB WITH				
INDLIB	-0.454	0.110	-4.134	0.000
CPI	-0.914	0.033	-27.393	0.000
CPOSWB	-0.783	0.104	-7.521	0.000
CPOSWB WITH				
INDLIB	0.470	0.104	4.525	0.000
CPI	0.693	0.100	6.915	0.000
INDLIB WITH				
CPI	0.387	0.116	3.324	0.001
Means				
INDLIB	5.022	0.983	5.107	0.000
CPI	3.263	0.415	7.865	0.000
Intercepts				
WRHPP	17.797	2.074	8.580	0.000
ENJLF	11.695	1.223	9.566	0.000
FLTPCFL	16.953	1.335	12.699	0.000
FLTDPR	6.611	0.928	7.125	0.000
FLTSD	7.634	0.857	8.908	0.000
FLTANX	6.373	0.419	15.208	0.000
Variances				
INDLIB	1.000	0.000	999.000	999.000
CPI	1.000	0.000	999.000	999.000
CPOSWB	1.000	0.000	999.000	999.000
CNEGWB	1.000	0.000	999.000	999.000
Residual Variances				
WRHPP	0.205	0.072	2.834	0.005
ENJLF	0.211	0.066	3.225	0.001
FLTPCFL	0.494	0.102	4.859	0.000
FLTDPR	0.157	0.068	2.326	0.020
FLTSD	-0.004	999.000	999.000	999.000
FLTANX	0.502	0.115	4.362	0.000

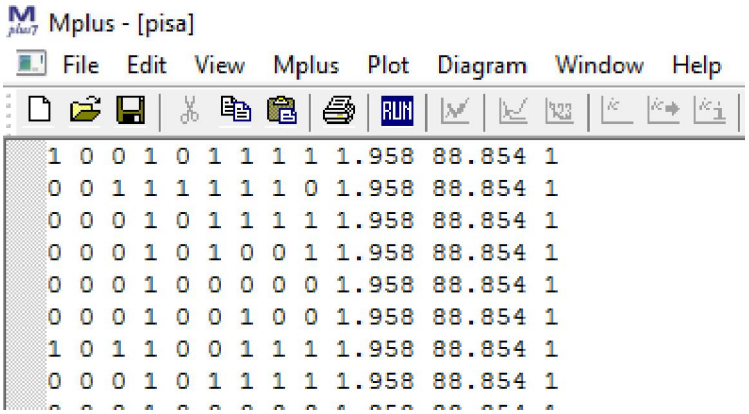
Direct effect of CPI on ENJLF (β)

Example 2 - Mathematical ability

Preparing the data for analysis in Mplus:

- Download the dataset from https://www.oecd.org/pisa/pisaproducts/
- Select the students who received Booklet 1 (BOOKID = 1)
- Select relevant variables (in this example: PM00FQ01 PM00GQ01 PM903Q03 PM909Q01 PM923Q04 PM924Q02 PM955Q01 PM995Q01 PM998Q02)
- Select the relevant country-level variables from the country-data (in this example: 'SC14Q02_mean' and 'SMRATIO_mean')
- Match the individual data to the country-level data (using the variable 'CNT')
- Recode all responses to numerical values
- Give numerical values to missing values (e.g. 999)
- Save dataset as .dat file without columnnames

Print screen of the prepared dataset:



The prepared dataset is available upon request by email (S.Jak@uva.nl)

- ALL INPUT FILES FOR EXAMPLE 2

Mplus-scripts for Example 2

The item labels for v1 to v9 as used by PISA are respectively: PM00FQ01, PM00GQ01, PM903Q03, PM909Q01, PM923Q04, PM924Q02, PM955Q01, PM995Q01 and PM998Q02.

Step 1 (obtaining intraclass correlations and fitting a null-model on the between-level):

```
DATA:
  FILE IS pisa.dat;
VARIABLE:
  NAMES ARE       v1-v9
                  short
                  stratio
                  cntryID;

  USEVARIABLES ARE v1-v9;
  CATEGORICAL ARE v1-v9;

  MISSING ARE     v1-v9 (7 8 9);
  CLUSTER IS      cntryID;

ANALYSIS: TYPE IS twolevel basic;
          ESTIMATOR IS WLSMV;
```

```
DATA:
  FILE IS pisa.dat;
VARIABLE:
  NAMES ARE       v1-v9
                  short
                  stratio
                  cntryID;

  USEVARIABLES ARE
                  v1-v9;
  CATEGORICAL ARE
                  v1-v9;

  MISSING ARE     v1-v9 (7 8 9);
  CLUSTER IS      cntryID;

ANALYSIS: TYPE IS twolevel;
          ESTIMATOR IS WLSMV;

MODEL:      %WITHIN%
            v1 with v2-v9;
            v2 with v3-v9;
            v3 with v4-v9;
            v4 with v5-v9;
            v5 with v6-v9;
            v6 with v7-v9;
            v7 with v8-v9;
            v8 with v9;

            %BETWEEN%
            v1-v9@0;
```

Step 2 (a measurement model within and a saturated model between):

All syntax except '`MODEL`' is identical to Step 1

```
MODEL:      %WITHIN%
            math by v1* v2-v9;
            math@1;

            %BETWEEN%
            v1 with v2-v9;
            v2 with v3-v9;
            v3 with v4-v9;
            v4 with v5-v9;
            v5 with v6-v9;
            v6 with v7-v9;
            v7 with v8-v9;
            v8 with v9;

            v1-v9;
```

Step 3a (strong factorial invariance model):

All syntax except '`MODEL`' is identical to Step 1

```
MODEL:      %WITHIN%
            math by v1* v2-v9(1-9);
            math@1;

            %BETWEEN%
            Bmath by v1* v2-v9 (1-9);
            Bmath;

            v1-v9@0;
```

Step 4 (adding observed between-level variables to the model

```
DATA:
  FILE IS pisa.dat;
VARIABLE:
  NAMES ARE       v1-v9
                  short
                  stratio
                  cntryID;

  USEVARIABLES ARE
                  v1-v9
                  short
                  stratio;

  CATEGORICAL ARE
                  v1-v9;

  BETWEEN ARE
                  short
                  stratio;

  MISSING ARE     v1-v9 (7 8 9);

  CLUSTER IS      cntryID;

  DEFINE:         stratio = stratio/100;

ANALYSIS: TYPE IS twolevel;
          ESTIMATOR IS WLSMV;

MODEL:      %WITHIN%
            math by v1* v2-v9 (1-9);
            math@1;

            %BETWEEN%
            Bmath by v1* v2-v9 (1-9);
            Bmath;

            Bmath with short stratio;
            short with stratio;

            v1-v9@0;

OUTPUT:     stdyx;
```

- ANNOTATED OUTPUT FOR EXAMPLE 2

Fit statistics of Step 1 (Chi-square statistic of the null-model)

```
MODEL FIT INFORMATION

Number of Free Parameters                       45

Chi-Square Test of Model Fit

          Value                             200.784*
          Degrees of Freedom                    45
          P-Value                           0.0000

*    The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
     for chi-square difference testing in the regular way.  MLM, MLR and WLSM
     chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
     and ULSMV difference testing is done using the DIFFTEST option.
```

Significant chi-square indicates significant country-level variance

```
Estimated Intraclass Correlations for the Y Variables

                Intraclass                Intraclass                Intraclass
Variable        Correlation    Variable   Correlation    Variable   Correlation

V1                0.069        V2           0.097        V3           0.138
V4                0.075        V5           0.104        V6           0.082
V7                0.057        V8           0.101        V9           0.107
```

ICCs range from .057 to .138

Fit statistics of Step 2 (measurement model at within-level)

```
     THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       63

Chi-Square Test of Model Fit

          Value                             36.736*
          Degrees of Freedom                    27
          P-Value                           0.1001

*    The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
     for chi-square difference testing in the regular way.  MLM, MLR and WLSM
     chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
     and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.005

CFI/TLI

          CFI                                0.998
          TLI                                0.995
```

$\chi^2_{(27)} = 36.74$, $p = .10$, RMSEA = .005, CFI = .998

Standardized parameter estimates of Step 2 (measurement model at within-level)

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
MATH BY				
V1	0.682	0.010	67.375	0.000
V2	0.600	0.013	46.561	0.000
V3	0.724	0.010	72.283	0.000
V4	0.487	0.019	25.211	0.000
V5	0.710	0.022	32.800	0.000
V6	0.701	0.010	68.867	0.000
V7	0.374	0.022	17.246	0.000
V8	0.745	0.012	61.353	0.000
V9	0.562	0.016	35.622	0.000
Variances				
MATH	1.000	0.000	999.000	999.000

Factor loadings (λ_w)

Factor variance (φ_w)

Residual variances (θ_w) are fixed at 1 for scaling and not provided in the output

Fit statistics of Step 3a (strong factorial invariance)

```
THE MODEL ESTIMATION TERMINATED NORMALLY


MODEL FIT INFORMATION

Number of Free Parameters                       19

Chi-Square Test of Model Fit

          Value                             84.642*
          Degrees of Freedom                    71
          P-Value                           0.1284

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.003

CFI/TLI

          CFI                                0.997
          TLI                                0.997
```

$\chi^2_{(71)} = 84.64$, $p = .12$, RMSEA = .003, CFI = .997

Parameter estimates of Step 3a (unstandardized)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
Within Level					
MATH BY					
V1	0.921	0.025	37.594	0.000	Factor loadings (λ_w)
V2	0.756	0.026	29.603	0.000	
V3	1.053	0.033	31.474	0.000	
V4	0.561	0.027	21.170	0.000	
V5	1.012	0.062	16.268	0.000	
V6	0.986	0.026	37.252	0.000	
V7	0.413	0.027	15.450	0.000	
V8	1.113	0.041	26.911	0.000	
V9	0.687	0.029	23.921	0.000	
Variances					
MATH	1.000	0.000	999.000	999.000	Factor variance (φ_w)
Between Level					
BMATH BY					
V1	0.921	0.025	37.594	0.000	Factor loadings (λ_b)
V2	0.756	0.026	29.603	0.000	
V3	1.053	0.033	31.474	0.000	
V4	0.561	0.027	21.170	0.000	
V5	1.012	0.062	16.268	0.000	
V6	0.986	0.026	37.252	0.000	
V7	0.413	0.027	15.450	0.000	
V8	1.113	0.041	26.911	0.000	
V9	0.687	0.029	23.921	0.000	
Thresholds					
V1$1	0.210	0.066	3.166	0.002	Thresholds (τ_b)
V2$1	1.753	0.066	26.398	0.000	
V3$1	0.838	0.117	7.141	0.000	
V4$1	-1.447	0.055	-26.417	0.000	
V5$1	1.483	0.047	31.322	0.000	
V6$1	-0.437	0.072	-6.103	0.000	
V7$1	-0.828	0.085	-9.764	0.000	
V8$1	-0.343	0.085	-4.036	0.000	
V9$1	-0.770	0.085	-9.050	0.000	
Variances					
BMATH	0.190	0.037	5.143	0.000	Factor variance (φ_b)
Residual Variances					
V1	0.000	0.000	999.000	999.000	Residual variances (θ_b) Fixed at zero
V2	0.000	0.000	999.000	999.000	
V3	0.000	0.000	999.000	999.000	
V4	0.000	0.000	999.000	999.000	
V5	0.000	0.000	999.000	999.000	
V6	0.000	0.000	999.000	999.000	
V7	0.000	0.000	999.000	999.000	
V8	0.000	0.000	999.000	999.000	
V9	0.000	0.000	999.000	999.000	

Calculating the ICC of the common factors using the factor variances:

ICC = $\varphi_b / (\varphi_b + \varphi_w)$

.190/ (.190 + 1) = .160

Parameter estimates of Step 3a (standardized)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
MATH BY				
V1	0.678	0.010	69.511	0.000
V2	0.603	0.013	46.510	0.000
V3	0.725	0.011	66.376	0.000
V4	0.489	0.018	27.837	0.000
V5	0.711	0.022	32.924	0.000
V6	0.702	0.010	73.505	0.000
V7	0.382	0.021	18.088	0.000
V8	0.744	0.012	60.229	0.000
V9	0.566	0.016	35.204	0.000
Variances				
MATH	1.000	0.000	999.000	999.000
Between Level				
BMATH BY				
V1	1.000	0.000	*********	0.000
V2	1.000	0.000	999.000	999.000
V3	1.000	0.000	*********	0.000
V4	1.000	0.000	999.000	999.000
V5	1.000	0.000	*********	0.000
V6	1.000	0.000	999.000	999.000
V7	1.000	0.000	*********	0.000
V8	1.000	0.000	999.000	999.000
V9	1.000	0.000	*********	0.000
Thresholds				
V1$1	0.154	0.049	3.159	0.002
V2$1	1.398	0.058	23.975	0.000
V3$1	0.577	0.076	7.597	0.000
V4$1	-1.262	0.053	-23.995	0.000
V5$1	1.042	0.059	17.758	0.000
V6$1	-0.311	0.051	-6.089	0.000
V7$1	-0.765	0.073	-10.486	0.000
V8$1	-0.229	0.060	-3.819	0.000
V9$1	-0.635	0.064	-9.987	0.000
Variances				
BMATH	1.000	0.000	999.000	999.000
Residual Variances				
V1	0.000	999.000	999.000	999.000
V2	0.000	999.000	999.000	999.000
V3	0.000	999.000	999.000	999.000
V4	0.000	999.000	999.000	999.000
V5	0.000	999.000	999.000	999.000
V6	0.000	999.000	999.000	999.000
V7	0.000	999.000	999.000	999.000
V8	0.000	999.000	999.000	999.000
V9	0.000	999.000	999.000	999.000

Factor loadings (λ_w)

Factor variance (φ_w)

Factor loadings (λ_b)

All standardized factor loadings are 1, because residual variance is zero

Thresholds (τ_b)

Factor variance (φ_b)

Residual variances (θ_b)

Fixed at zero

Fit statistics of Step 4 (Adding observed variables)

```
MODEL FIT INFORMATION

Number of Free Parameters                       26

Chi-Square Test of Model Fit

          Value                             98.660*
          Degrees of Freedom                    87
          P-Value                           0.1848

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.003

CFI/TLI

          CFI                                0.998
          TLI                                0.998
```

$\chi^2_{(87)} = 98.66$, $p = .18$, RMSEA = .003, CFI = .998

Parameter estimates of Step 4 (unstandardized)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
Within Level					
MATH BY					
V1	0.921	0.025	37.589	0.000	Factor loadings (λ_w)
V2	0.756	0.026	29.607	0.000	
V3	1.051	0.034	31.163	0.000	
V4	0.562	0.027	21.063	0.000	
V5	1.012	0.063	16.124	0.000	
V6	0.986	0.026	37.249	0.000	
V7	0.414	0.027	15.396	0.000	
V8	1.113	0.041	26.952	0.000	
V9	0.688	0.029	23.814	0.000	
Variances					
MATH	1.000	0.000	999.000	999.000	Factor variance (φ_w)
Between Level					
BMATH BY					
V1	0.921	0.025	37.589	0.000	Factor loadings (λ_b)
V2	0.756	0.026	29.607	0.000	
V3	1.051	0.034	31.163	0.000	
V4	0.562	0.027	21.063	0.000	
V5	1.012	0.063	16.124	0.000	
V6	0.986	0.026	37.249	0.000	
V7	0.414	0.027	15.396	0.000	
V8	1.113	0.041	26.952	0.000	
V9	0.688	0.029	23.814	0.000	
BMATH WITH					Covariances between common factor and contextual variables
SHORT	0.009	0.021	0.433	0.665	
STRATIO	-0.040	0.020	-1.965	0.049	
SHORT WITH					
STRATIO	0.023	0.019	1.213	0.225	
Means					Means of contextual variables
SHORT	1.518	0.059	25.785	0.000	
STRATIO	1.085	0.074	14.607	0.000	
Thresholds					Thresholds (τ_b)
V1$1	0.210	0.066	3.167	0.002	
V2$1	1.753	0.067	26.354	0.000	
V3$1	0.837	0.117	7.122	0.000	
V4$1	-1.448	0.055	-26.459	0.000	
V5$1	1.483	0.047	31.617	0.000	
V6$1	-0.437	0.072	-6.106	0.000	
V7$1	-0.828	0.085	-9.755	0.000	
V8$1	-0.343	0.085	-4.035	0.000	
V9$1	-0.771	0.085	-9.043	0.000	
Variances					Variances of common factor and contextual variables
SHORT	0.098	0.028	3.464	0.001	
STRATIO	0.152	0.035	4.364	0.000	
BMATH	0.190	0.037	5.143	0.000	
Residual Variances					Residual variances (θ_b)
V1	0.000	0.000	999.000	999.000	
V2	0.000	0.000	999.000	999.000	
V3	0.000	0.000	999.000	999.000	
V4	0.000	0.000	999.000	999.000	
V5	0.000	0.000	999.000	999.000	
V6	0.000	0.000	999.000	999.000	
V7	0.000	0.000	999.000	999.000	
V8	0.000	0.000	999.000	999.000	
V9	0.000	0.000	999.000	999.000	

Parameter estimates of Step 4 (standardized)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Within Level				
MATH BY				
V1	0.678	0.010	69.506	0.000
V2	0.603	0.013	46.525	0.000
V3	0.725	0.011	65.592	0.000
V4	0.490	0.018	27.724	0.000
V5	0.711	0.022	32.629	0.000
V6	0.702	0.010	73.454	0.000
V7	0.382	0.021	18.031	0.000
V8	0.744	0.012	60.310	0.000
V9	0.567	0.016	35.070	0.000
Variances				
MATH	1.000	0.000	999.000	999.000
Between Level				
BMATH BY				
V1	1.000	0.000	999.000	999.000
V2	1.000	0.000	999.000	999.000
V3	1.000	0.000	999.000	999.000
V4	1.000	0.000	999.000	999.000
V5	1.000	0.000	*********	0.000
V6	1.000	0.000	*********	0.000
V7	1.000	0.000	999.000	999.000
V8	1.000	0.000	999.000	999.000
V9	1.000	0.000	*********	0.000
BMATH WITH				
SHORT	0.066	0.150	0.442	0.659
STRATIO	-0.236	0.112	-2.098	0.036
SHORT WITH				
STRATIO	0.189	0.147	1.292	0.196
Means				
SHORT	4.849	0.635	7.636	0.000
STRATIO	2.786	0.281	9.910	0.000
Thresholds				
V1$1	0.154	0.049	3.159	0.002
V2$1	1.398	0.058	23.975	0.000
V3$1	0.577	0.076	7.597	0.000
V4$1	-1.262	0.053	-23.995	0.000
V5$1	1.042	0.059	17.758	0.000
V6$1	-0.311	0.051	-6.089	0.000
V7$1	-0.765	0.073	-10.486	0.000
V8$1	-0.229	0.060	-3.819	0.000
V9$1	-0.635	0.064	-9.987	0.000
Variances				
SHORT	1.000	0.000	999.000	999.000
STRATIO	1.000	0.000	999.000	999.000
BMATH	1.000	0.000	999.000	999.000
Residual Variances				
V1	0.000	999.000	999.000	999.000
V2	0.000	999.000	999.000	999.000
V3	0.000	999.000	999.000	999.000
V4	0.000	999.000	999.000	999.000
V5	0.000	999.000	999.000	999.000
V6	0.000	999.000	999.000	999.000
V7	0.000	999.000	999.000	999.000
V8	0.000	999.000	999.000	999.000
V9	0.000	999.000	999.000	999.000

Factor loadings (λ_w)

Factor variance (φ_w)

Factor loadings (λ_b)

Correlations between common factor and contextual variables

Means of contextual variables

Thresholds (τ_b)

Variances of common factor and contextual variables

Residual variances (θ_b)