

Multiple Group Invariance Example (from Brown Chapter 7): Major Depression Criteria across Men and Women ($n = 345$ each)

9 items rated by clinicians on a scale of 0 to 8 (0 = none, 8 = very severely disturbing/disabling)

1. Depressed mood
2. Loss of interest in usual activities
3. Weight/appetite change
4. Sleep disturbance
5. Psychomotor agitation/retardation
6. Fatigue/loss of energy
7. Feelings of worthless/guilt
8. Concentration difficulties
9. Thoughts of death/suicidality

Mplus Code to Read in Data:

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TITLE:      Multiple Group Invariance
DATA:      FILE IS MDDALL.dat;           ! Don't need path if in same directory
              FORMAT IS free;             ! Default
              TYPE IS INDIVIDUAL;        ! Default

VARIABLE:  NAMES ARE SEX M1-M9;        ! Every variable in data set
              USEVARIABLES ARE M1-M9;    ! Every variable in MODEL
              GROUPING IS SEX (0=F 1=M); ! Specify grouping variable
              MISSING ARE ALL (99999);   ! Make sure to specify all missing values

ANALYSIS:  TYPE IS GENERAL;            ! Default
              ESTIMATOR IS ML;           ! Default if TYPE=GENERAL and all continuous items

MODEL:      (model syntax goes here, to be changed for each model)

OUTPUT:    SAMPSTAT                    ! Sample descriptives to verify data
              MODINDICES (4)             ! Voodoo to improve model (list if  $\chi^2 > 4$ )
              STDYX                      ! Requests fully standardized solution
              RESIDUAL;                  ! Requests standardized and normalized residuals

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In each case, the model for the reference group (women) is the same and what changes is how the men are allowed to differ. There are two ways to constrain parameters across groups. One is to leave it off the alternative group model, and the other is to use labeled constraints: () after the parameter, only one allowed before a semi-colon. We will use the latter because it is more general.

Model 1. Configural Invariance Model (Everything separate across groups)

<pre> ! REFERENCE GROUP CONFIGURAL MODEL; MODEL: ! Factor loadings (1=marker, rest free) DEPRESS BY M1@1 (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (FREE IN CONFIGURAL MODEL) DEPRESS*; ! Factor mean is 0 (required by Mplus) [DEPRESS@0]; </pre>	<pre> ! MODEL 1: CONFIGURAL MODEL FOR MEN MODEL M: ! Factor loadings (1=marker, rest free) DEPRESS BY M1@1 M2-M9*; ! Item intercepts (all free) [M1-M9*]; ! Residual variances (all free) M1-M9*; ! Residual covariance (free for 1&2) M1 WITH M2*; ! Factor variance (ALWAYS FREE) DEPRESS*; ! Factor mean is still 0 [DEPRESS@0]; </pre>
<pre> Chi-Square Test of Model Fit Value 98.911 Degrees of Freedom 52 P-Value 0.0001 Chi-Square Contributions From Each Group W 52.954 M 45.957 Chi-Square Test of Model Fit for the Baseline Model Value 1343.575 Degrees of Freedom 72 P-Value 0.0000 CFI/TLI CFI 0.963 TLI 0.949 </pre>	<pre> Information Criteria Number of Free Parameters 56 Akaike (AIC) 27525.796 Bayesian (BIC) 27784.520 Sample-Size Adjusted BIC 27606.698 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.049 90 Percent C.I. 0.034 0.064 SRMR (Standardized Root Mean Square Residual) Value 0.039 </pre>

UNSTANDARDIZED MODEL RESULTS - NOTE ALL PARAMETERS (EXCEPT MARKER LOADING AND FACTOR MEANS) DIFFER ACROSS GROUPS

Group W					Group M				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY (FACTOR LOADINGS)					DEPRESS BY				
M1	1.000	0.000	999.000	999.000	M1	1.000	0.000	999.000	999.000
M2	1.107	0.086	12.878	0.000	M2	1.236	0.099	12.520	0.000
M3	0.729	0.102	7.141	0.000	M3	0.786	0.138	5.713	0.000
M4	0.911	0.113	8.092	0.000	M4	1.165	0.158	7.373	0.000
M5	0.812	0.109	7.438	0.000	M5	0.959	0.141	6.794	0.000
M6	0.924	0.101	9.134	0.000	M6	1.132	0.150	7.542	0.000
M7	0.611	0.096	6.362	0.000	M7	0.766	0.141	5.426	0.000
M8	0.979	0.108	9.079	0.000	M8	1.019	0.143	7.118	0.000
M9	0.484	0.083	5.827	0.000	M9	0.632	0.109	5.793	0.000
M1 WITH (RESIDUAL COVARIANCE)					M1 WITH				
M2	0.393	0.151	2.605	0.009	M2	0.920	0.164	5.624	0.000
Means (FACTOR MEAN)					Means				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	0.000	0.000	999.000	999.000
Intercepts (ITEM MEANS PER GROUP IN THIS SCALING)					Intercepts				
M1	4.184	0.089	47.258	0.000	M1	4.171	0.082	50.607	0.000
M2	3.725	0.104	35.848	0.000	M2	3.685	0.104	35.414	0.000
M3	1.952	0.108	18.058	0.000	M3	1.739	0.108	16.098	0.000
M4	3.589	0.114	31.458	0.000	M4	3.357	0.115	29.160	0.000
M5	2.256	0.110	20.522	0.000	M5	2.235	0.109	20.560	0.000
M6	3.955	0.103	38.237	0.000	M6	3.661	0.109	33.598	0.000
M7	3.869	0.106	36.382	0.000	M7	3.421	0.118	29.014	0.000
M8	3.595	0.111	32.331	0.000	M8	3.517	0.112	31.372	0.000
M9	1.205	0.092	13.053	0.000	M9	1.259	0.092	13.649	0.000
Variances (FACTOR VARIANCE)					Variances				
DEPRESS	1.564	0.226	6.914	0.000	DEPRESS	1.049	0.185	5.653	0.000
Residual Variances (ITEM ERROR VARIANCES)					Residual Variances				
M1	1.375	0.159	8.652	0.000	M1	1.498	0.154	9.722	0.000
M2	2.132	0.227	9.409	0.000	M2	2.459	0.248	9.934	0.000
M3	3.551	0.277	12.810	0.000	M3	3.727	0.292	12.777	0.000
M4	3.583	0.293	12.222	0.000	M4	3.547	0.309	11.472	0.000
M5	3.501	0.282	12.410	0.000	M5	3.467	0.282	12.284	0.000
M6	2.677	0.227	11.784	0.000	M6	3.111	0.273	11.406	0.000
M7	3.658	0.280	13.080	0.000	M7	4.599	0.354	13.001	0.000
M8	3.137	0.264	11.894	0.000	M8	3.626	0.298	12.183	0.000
M9	2.831	0.214	13.203	0.000	M9	2.770	0.215	12.882	0.000

Model 2. Metric Invariance Model (loadings held equal across groups)

<pre> ! REFERENCE GROUP METRIC INVARIANCE MODEL; MODEL: ! Factor loadings (NO MARKER -- ALL FREE NOW) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (NOW FIXED=1 IN METRIC MODEL) DEPRESS@1; ! Factor mean is 0 (required by Mplus) [DEPRESS@0]; </pre>	<pre> ! MODEL 2: METRIC ("WEAK") INVARIANCE MODEL FOR MEN MODEL M: ! Factor loadings (ALL NOW EQUAL TO WOMEN) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1-M9*]; ! Residual variances (all free) M1-M9*; ! Residual covariance (free for 1&2) M1 WITH M2*; ! Factor variance (STILL FREE) DEPRESS*; ! Factor mean is still 0 [DEPRESS@0]; </pre>
<pre> Chi-Square Test of Model Fit Value 102.839 Degrees of Freedom 60 P-Value 0.0005 Chi-Square Contributions From Each Group W 54.745 M 48.094 CFI/TLI CFI 0.966 TLI 0.960 </pre>	<pre> Information Criteria Number of Free Parameters 48 Akaike (AIC) 27513.724 Bayesian (BIC) 27735.488 Sample-Size Adjusted BIC 27583.069 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.044 90 Percent C.I. 0.029 0.058 SRMR (Standardized Root Mean Square Residual) Value 0.042 </pre>

Did model fit get significantly worse?

UNSTANDARDIZED MODEL RESULTS - NOTE NOW FACTOR LOADINGS ARE HELD EQUAL

Group W					Group M				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
M1	1.180	0.077	15.297	0.000	M1	1.180	0.077	15.297	0.000
M2	1.386	0.092	15.029	0.000	M2	1.386	0.092	15.029	0.000
M3	0.888	0.092	9.656	0.000	M3	0.888	0.092	9.656	0.000
M4	1.202	0.098	12.213	0.000	M4	1.202	0.098	12.213	0.000
M5	1.035	0.094	11.053	0.000	M5	1.035	0.094	11.053	0.000
M6	1.191	0.090	13.240	0.000	M6	1.191	0.090	13.240	0.000
M7	0.792	0.094	8.450	0.000	M7	0.792	0.094	8.450	0.000
M8	1.186	0.095	12.458	0.000	M8	1.186	0.095	12.458	0.000
M9	0.647	0.078	8.251	0.000	M9	0.647	0.078	8.251	0.000
M1 WITH					M1 WITH				
M2	0.439	0.142	3.088	0.002	M2	0.862	0.152	5.667	0.000
Means					Means				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	0.000	0.000	999.000	999.000
Intercepts					Intercepts				
M1	4.184	0.087	48.103	0.000	M1	4.171	0.084	49.725	0.000
M2	3.725	0.104	35.750	0.000	M2	3.685	0.104	35.374	0.000
M3	1.952	0.108	18.134	0.000	M3	1.739	0.108	16.028	0.000
M4	3.589	0.115	31.130	0.000	M4	3.357	0.114	29.475	0.000
M5	2.256	0.110	20.481	0.000	M5	2.235	0.108	20.602	0.000
M6	3.955	0.104	37.973	0.000	M6	3.661	0.108	33.853	0.000
M7	3.869	0.107	36.201	0.000	M7	3.421	0.117	29.164	0.000
M8	3.595	0.110	32.601	0.000	M8	3.517	0.113	31.086	0.000
M9	1.205	0.093	12.956	0.000	M9	1.259	0.092	13.750	0.000
Variances					Variances				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	0.863	0.118	7.292	0.000
Residual Variances					Residual Variances				
M1	1.444	0.151	9.591	0.000	M1	1.436	0.145	9.875	0.000
M2	2.151	0.216	9.971	0.000	M2	2.412	0.233	10.359	0.000
M3	3.556	0.276	12.904	0.000	M3	3.731	0.289	12.918	0.000
M4	3.540	0.289	12.269	0.000	M4	3.617	0.300	12.067	0.000
M5	3.479	0.277	12.547	0.000	M5	3.488	0.278	12.541	0.000
M6	2.648	0.223	11.848	0.000	M6	3.161	0.264	11.956	0.000
M7	3.656	0.279	13.108	0.000	M7	4.619	0.351	13.175	0.000
M8	3.153	0.261	12.099	0.000	M8	3.587	0.291	12.314	0.000
M9	2.827	0.214	13.211	0.000	M9	2.781	0.213	13.083	0.000

Modification indices do not suggest that freeing any loadings between groups would help, so we proceed with loadings fully invariant.

Model 3a. Scalar Invariance Model (all loadings and intercepts held equal across groups)

<pre> ! REFERENCE GROUP SCALAR INVARIANCE MODEL (SAME); MODEL: ! Factor loadings (STILL ALL FREE) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (STILL FIXED=1) DEPRESS@1; ! Factor mean is 0 (required by Mplus) [DEPRESS@0]; </pre>	<pre> ! MODEL 3A: SCALAR ("STRONG") INVARIANCE MODEL FOR MEN MODEL M: ! Factor loadings (ALL STILL EQUAL TO WOMEN) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (ALL NOW EQUAL TO WOMEN NOW) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1-M9*; ! Residual covariance (free for 1&2) M1 WITH M2*; ! Factor variance (STILL FREE) DEPRESS*; ! Factor mean is NOW FREE [DEPRESS*]; </pre>
<pre> Chi-Square Test of Model Fit Value 115.309 Degrees of Freedom 68 P-Value 0.0003 Chi-Square Contributions From Each Group W 60.713 M 54.596 CFI/TLI CFI 0.963 TLI 0.961 </pre>	<pre> Information Criteria Number of Free Parameters 40 Akaike (AIC) 27510.194 Bayesian (BIC) 27694.997 Sample-Size Adjusted BIC 27567.981 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.043 90 Percent C.I. 0.029 0.056 SRMR (Standardized Root Mean Square Residual) Value 0.046 </pre>

Did model fit get significantly worse?

UNSTANDARDIZED MODEL RESULTS - NOTE NOW FACTOR LOADINGS AND INTERCEPTS ARE HELD EQUAL

Group W					Group M				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
M1	1.171	0.077	15.193	0.000	M1	1.171	0.077	15.193	0.000
M2	1.377	0.092	14.944	0.000	M2	1.377	0.092	14.944	0.000
M3	0.894	0.092	9.722	0.000	M3	0.894	0.092	9.722	0.000
M4	1.208	0.098	12.280	0.000	M4	1.208	0.098	12.280	0.000
M5	1.033	0.093	11.056	0.000	M5	1.033	0.093	11.056	0.000
M6	1.199	0.090	13.308	0.000	M6	1.199	0.090	13.308	0.000
M7	0.803	0.094	8.533	0.000	M7	0.803	0.094	8.533	0.000
M8	1.184	0.095	12.446	0.000	M8	1.184	0.095	12.446	0.000
M9	0.641	0.078	8.178	0.000	M9	0.641	0.078	8.178	0.000
M1 WITH					M1 WITH				
M2	0.454	0.142	3.187	0.001	M2	0.878	0.153	5.757	0.000
Means					Means (NOW REPRESENTS DIFFERENCE IN FACTOR MEANS)				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	-0.112	0.081	-1.375	0.169
Intercepts					Intercepts				
M1	4.240	0.078	54.506	0.000	M1	4.240	0.078	54.506	0.000
M2	3.773	0.093	40.526	0.000	M2	3.773	0.093	40.526	0.000
M3	1.897	0.086	22.163	0.000	M3	1.897	0.086	22.163	0.000
M4	3.541	0.096	36.800	0.000	M4	3.541	0.096	36.800	0.000
M5	2.303	0.089	25.849	0.000	M5	2.303	0.089	25.849	0.000
M6	3.882	0.090	42.895	0.000	M6	3.882	0.090	42.895	0.000
M7	3.711	0.087	42.812	0.000	M7	3.711	0.087	42.812	0.000
M8	3.620	0.093	38.779	0.000	M8	3.620	0.093	38.779	0.000
M9	1.268	0.071	17.878	0.000	M9	1.268	0.071	17.878	0.000
Variances					Variances				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	0.864	0.119	7.279	0.000
Residual Variances					Residual Variances				
M1	1.460	0.151	9.663	0.000	M1	1.451	0.146	9.943	0.000
M2	2.166	0.216	10.025	0.000	M2	2.431	0.233	10.411	0.000
M3	3.555	0.276	12.883	0.000	M3	3.730	0.289	12.896	0.000
M4	3.536	0.289	12.243	0.000	M4	3.611	0.300	12.035	0.000
M5	3.478	0.277	12.547	0.000	M5	3.489	0.278	12.539	0.000
M6	2.648	0.224	11.801	0.000	M6	3.161	0.265	11.908	0.000
M7	3.682	0.282	13.045	0.000	M7	4.657	0.355	13.108	0.000
M8	3.154	0.261	12.094	0.000	M8	3.588	0.291	12.312	0.000
M9	2.833	0.215	13.208	0.000	M9	2.788	0.213	13.083	0.000

Model 3b: Although the overall test of scalar invariance holds, the modification indices suggest that freeing the intercept for item 7 between groups would help significantly:

MODEL MODIFICATION INDICES
 Minimum M.I. value for printing the modification index 4.000

	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
Group W				
Means/Intercepts/Thresholds				
[M7]	6.070	0.158	0.158	0.076
Group M				
Means/Intercepts/Thresholds				
[M7]	6.074	-0.219	-0.219	-0.096

Old Intercept 7: 3.711
 New Women Intercept 7: 3.869 (≈3.711 + .158)
 New Men Intercept 7: 3.493 (≈3.711 + -.219)

Did freeing intercept 7 help significantly?

Now re-test for scalar invariance:

! Item intercepts (all free)	! Item intercepts (NOW ALL EQUAL TO WOMEN EXCEPT 7)																																																																																																																																												
<p>[M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9);</p>	<p>[M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*]; [M8*] (I8); [M9*] (I9);</p>																																																																																																																																												
<p>Chi-Square Test of Model Fit</p> <table border="0" style="width: 100%;"> <tr> <td style="padding-left: 20px;">Value</td> <td style="text-align: right;">109.216</td> </tr> <tr> <td style="padding-left: 20px;">Degrees of Freedom</td> <td style="text-align: right;">67</td> </tr> <tr> <td style="padding-left: 20px;">P-Value</td> <td style="text-align: right;">0.0009</td> </tr> </table> <p>Chi-Square Contributions From Each Group</p> <table border="0" style="width: 100%;"> <tr> <td style="padding-left: 20px;">W</td> <td style="text-align: right;">57.898</td> </tr> <tr> <td style="padding-left: 20px;">M</td> <td style="text-align: right;">51.317</td> </tr> </table> <p>CFI/TLI</p> <table border="0" style="width: 100%;"> <tr> <td style="padding-left: 20px;">CFI</td> <td style="text-align: right;">0.967</td> </tr> <tr> <td style="padding-left: 20px;">TLI</td> <td style="text-align: right;">0.964</td> </tr> </table>	Value	109.216	Degrees of Freedom	67	P-Value	0.0009	W	57.898	M	51.317	CFI	0.967	TLI	0.964	<p>Information Criteria</p> <table border="0" style="width: 100%;"> <tr> <td style="padding-left: 20px;">Number of Free Parameters</td> <td style="text-align: right;">41</td> </tr> <tr> <td style="padding-left: 20px;">Akaike (AIC)</td> <td style="text-align: right;">27506.100</td> </tr> <tr> <td style="padding-left: 20px;">Bayesian (BIC)</td> <td style="text-align: right;">27695.523</td> </tr> <tr> <td style="padding-left: 20px;">Sample-Size Adjusted BIC</td> <td style="text-align: right;">27565.332</td> </tr> <tr> <td colspan="2" style="padding-left: 20px;">(n* = (n + 2) / 24)</td> </tr> </table> <p>RMSEA (Root Mean Square Error Of Approximation)</p> <table border="0" style="width: 100%;"> <tr> <td style="padding-left: 20px;">Estimate</td> <td style="text-align: right;">0.041</td> </tr> <tr> <td style="padding-left: 20px;">90 Percent C.I.</td> <td style="text-align: right;">0.026 0.055</td> </tr> </table> <p>SRMR (Standardized Root Mean Square Residual)</p> <table border="0" style="width: 100%;"> <tr> <td style="padding-left: 20px;">Value</td> <td style="text-align: right;">0.044</td> </tr> </table>	Number of Free Parameters	41	Akaike (AIC)	27506.100	Bayesian (BIC)	27695.523	Sample-Size Adjusted BIC	27565.332	(n* = (n + 2) / 24)		Estimate	0.041	90 Percent C.I.	0.026 0.055	Value	0.044																																																																																																														
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Model 4. Residual Variance Invariance Model (error variances held equal for all except item 7)

<pre> ! REFERENCE GROUP RESIDUAL INVARIANCE MODEL (SAME); MODEL: ! Factor loadings (STILL ALL FREE) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (FIXED=1 IN METRIC MODEL) DEPRESS@1; ! Factor mean is 0 (required by Mplus) [DEPRESS@0]; </pre>	<pre> ! MODEL 4: RESIDUAL ("STRICT") INVARIANCE MODEL FOR MEN MODEL M: ! Factor loadings (ALL STILL EQUAL TO WOMEN) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (ALL STILL EQUAL TO WOMEN EXCEPT FOR 7) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*]; [M8*] (I8); [M9*] (I9); ! Residual variances (ALL EQUAL TO WOMEN NOW EXCEPT 7) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7*; M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2*; ! Factor variance (STILL FREE) DEPRESS*; ! Factor mean is STILL FREE [DEPRESS*]; </pre>
<pre> Chi-Square Test of Model Fit Value 114.059 Degrees of Freedom 75 P-Value 0.0025 Chi-Square Contributions From Each Group W 60.755 M 53.304 CFI/TLI CFI 0.969 TLI 0.971 </pre>	<pre> Information Criteria Number of Free Parameters 33 Akaike (AIC) 27494.944 Bayesian (BIC) 27647.406 Sample-Size Adjusted BIC 27542.618 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.037 90 Percent C.I. 0.022 0.051 SRMR (Standardized Root Mean Square Residual) Value 0.048 </pre>

Did model fit get significantly worse?

UNSTANDARDIZED MODEL RESULTS - NOTE NOW FACTOR LOADINGS, INTERCEPTS (except 7), AND RESIDUAL VARIANCES (except 7) ARE HELD EQUAL

Group W					Group M				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
M1	1.167	0.077	15.231	0.000	M1	1.167	0.077	15.231	0.000
M2	1.372	0.092	14.877	0.000	M2	1.372	0.092	14.877	0.000
M3	0.888	0.092	9.684	0.000	M3	0.888	0.092	9.684	0.000
M4	1.203	0.098	12.266	0.000	M4	1.203	0.098	12.266	0.000
M5	1.031	0.093	11.076	0.000	M5	1.031	0.093	11.076	0.000
M6	1.197	0.091	13.186	0.000	M6	1.197	0.091	13.186	0.000
M7	0.787	0.093	8.423	0.000	M7	0.787	0.093	8.423	0.000
M8	1.178	0.095	12.367	0.000	M8	1.178	0.095	12.367	0.000
M9	0.639	0.078	8.196	0.000	M9	0.639	0.078	8.196	0.000
M1 WITH (= to correlation of .27)					M1 WITH (= to correlation of .46)				
M2	0.485	0.130	3.730	0.000	M2	0.833	0.121	6.883	0.000
Means					Means				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	-0.091	0.082	-1.110	0.267
Intercepts					Intercepts				
M1	4.229	0.078	54.413	0.000	M1	4.229	0.078	54.413	0.000
M2	3.763	0.093	40.289	0.000	M2	3.763	0.093	40.289	0.000
M3	1.886	0.085	22.057	0.000	M3	1.886	0.085	22.057	0.000
M4	3.528	0.096	36.683	0.000	M4	3.528	0.096	36.683	0.000
M5	2.292	0.089	25.748	0.000	M5	2.292	0.089	25.748	0.000
M6	3.862	0.091	42.385	0.000	M6	3.862	0.091	42.385	0.000
M7	3.869	0.107	36.251	0.000	M7	3.493	0.123	28.439	0.000
M8	3.610	0.094	38.529	0.000	M8	3.610	0.094	38.529	0.000
M9	1.261	0.071	17.815	0.000	M9	1.261	0.071	17.815	0.000
Variances					Variances				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	0.883	0.120	7.359	0.000
Residual Variances					Residual Variances				
M1	1.447	0.111	13.094	0.000	M1	1.447	0.111	13.094	0.000
M2	2.300	0.167	13.785	0.000	M2	2.300	0.167	13.785	0.000
M3	3.646	0.202	18.081	0.000	M3	3.646	0.202	18.081	0.000
M4	3.574	0.212	16.821	0.000	M4	3.574	0.212	16.821	0.000
M5	3.479	0.199	17.507	0.000	M5	3.479	0.199	17.507	0.000
M6	2.903	0.177	16.387	0.000	M6	2.903	0.177	16.387	0.000
M7	3.653	0.279	13.088	0.000	M7	4.629	0.351	13.196	0.000
M8	3.367	0.198	16.990	0.000	M8	3.367	0.198	16.990	0.000
M9	2.809	0.152	18.492	0.000	M9	2.809	0.152	18.492	0.000

Modification indices do not suggest that freeing any residual variances between groups would help, so we proceed with them fully invariant.

Model 5. Residual Covariance Invariance Model (error covariance for 1-2 now held equal)

<pre> ! REFERENCE GROUP RES COVARIANCE INVARIANCE MODEL (SAME); MODEL: ! Factor loadings (STILL ALL FREE) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (FIXED=1 IN METRIC MODEL) DEPRESS@1; ! Factor mean is 0 (required by Mplus) [DEPRESS@0]; </pre>	<pre> ! MODEL 5: RES COVARIANCE INVARIANCE MODEL FOR MEN MODEL M: ! Factor loadings (ALL STILL EQUAL TO WOMEN) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (ALL STILL EQUAL TO WOMEN EXCEPT FOR 7) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*]; [M8*] (I8); [M9*] (I9); ! Residual variances (ALL EQUAL TO WOMEN NOW EXCEPT 7) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7*; M8* (E8); M9* (E9); ! Residual covariance (NOW EQUAL TO WOMEN) M1 WITH M2* (ECOV12); ! Factor variance (STILL FREE) DEPRESS*; ! Factor mean is STILL FREE [DEPRESS*]; </pre>
<pre> Chi-Square Test of Model Fit Value 123.351 Degrees of Freedom 76 P-Value 0.0005 Chi-Square Contributions From Each Group W 65.100 M 58.250 CFI/TLI CFI 0.963 TLI 0.965 </pre>	<pre> Information Criteria Number of Free Parameters 32 Akaike (AIC) 27502.235 Bayesian (BIC) 27650.078 Sample-Size Adjusted BIC 27548.465 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.041 90 Percent C.I. 0.027 0.054 SRMR (Standardized Root Mean Square Residual) Value 0.048 </pre>

Did model fit get significantly worse?

M1	WITH								
	M2	0.671	0.111	6.034	0.000				→ constrained residual covariance estimate

STRUCTURAL INVARIANCE TESTS
Model 6. Factor Variance Invariance Model

<pre> ! REFERENCE GROUP FACTOR VARIANCE INVARIANCE MODEL; MODEL: ! Factor loadings (STILL ALL FREE) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (FIXED=1 IN METRIC MODEL) DEPRESS@1; ! Factor mean is 0 (required by Mplus) [DEPRESS@0]; </pre>	<pre> ! MODEL 6: FACTOR VARIANCE INVARIANCE MODEL FOR MEN MODEL M: ! Factor loadings (ALL STILL EQUAL TO WOMEN) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (ALL STILL EQUAL TO WOMEN EXCEPT FOR 7) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*]; [M8*] (I8); [M9*] (I9); ! Residual variances (ALL EQUAL TO WOMEN NOW EXCEPT 7) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7*; M8* (E8); M9* (E9); ! Residual covariance (NOW BACK TO FREE) M1 WITH M2*; ! Factor variance (NOW FIXED TO 1 ALSO) DEPRESS@1; ! Factor mean is STILL FREE [DEPRESS*]; </pre>
<pre> Chi-Square Test of Model Fit Value 114.904 Degrees of Freedom 76 P-Value 0.0026 Chi-Square Contributions From Each Group W 61.214 M 53.690 CFI/TLI CFI 0.969 TLI 0.971 </pre>	<pre> Information Criteria Number of Free Parameters 32 Akaike (AIC) 27493.789 Bayesian (BIC) 27641.631 Sample-Size Adjusted BIC 27540.019 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.037 90 Percent C.I. 0.022 0.050 SRMR (Standardized Root Mean Square Residual) Value 0.050 </pre>

Did model fit get significantly worse?

STRUCTURAL INVARIANCE TESTS
Model 7. Factor Mean Invariance Model

<pre>! REFERENCE GROUP FACTOR VARIANCE INVARIANCE MODEL; MODEL: ! Factor loadings (STILL ALL FREE) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (all free) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*] (I7); [M8*] (I8); [M9*] (I9); ! Residual variances (all free) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7* (E7); M8* (E8); M9* (E9); ! Residual covariance (free for 1&2) M1 WITH M2* (ECOV12); ! Factor variance (FIXED=1 IN METRIC MODEL) DEPRESS@1; ! Factor mean is 0 (required by Mplus) [DEPRESS@0];</pre>	<pre>! MODEL 6: FACTOR VARIANCE INVARIANCE MODEL FOR MEN MODEL M: ! Factor loadings (ALL STILL EQUAL TO WOMEN) DEPRESS BY M1* (L1) M2* (L2) M3* (L3) M4* (L4) M5* (L5) M6* (L6) M7* (L7) M8* (L8) M9* (L9); ! Item intercepts (ALL STILL EQUAL TO WOMEN EXCEPT FOR 7) [M1*] (I1); [M2*] (I2); [M3*] (I3); [M4*] (I4); [M5*] (I5); [M6*] (I6); [M7*]; [M8*] (I8); [M9*] (I9); ! Residual variances (ALL EQUAL TO WOMEN NOW EXCEPT 7) M1* (E1); M2* (E2); M3* (E3); M4* (E4); M5* (E5); M6* (E6); M7*; M8* (E8); M9* (E9); ! Residual covariance (NOW BACK TO FREE) M1 WITH M2*; ! Factor variance (NOW FIXED TO 1 ALSO) DEPRESS@1; ! Factor mean is NOW FIXED TO 0 TOO [DEPRESS@0];</pre>
<pre>Chi-Square Test of Model Fit Value 116.143 Degrees of Freedom 77 P-Value 0.0026 Chi-Square Contributions From Each Group W 61.790 M 54.353 CFI/TLI CFI 0.969 TLI 0.971</pre>	<pre>Information Criteria Number of Free Parameters 31 Akaike (AIC) 27493.027 Bayesian (BIC) 27636.250 Sample-Size Adjusted BIC 27537.813 (n* = (n + 2) / 24) RMSEA (Root Mean Square Error Of Approximation) Estimate 0.037 90 Percent C.I. 0.022 0.050 SRMR (Standardized Root Mean Square Residual) Value 0.050</pre>

Means
 DEPRESS -0.094 0.084 -1.112 0.266 → mean difference from PREVIOUS model 6 WAS NOT SIGNIFICANT

OUR FINAL INVARIANCE MODEL - PARTIAL MEASUREMENT INVARIANCE, FULL STRUCTURAL INVARIANCE

Group W					Group M				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
M1	1.135	0.064	17.797	0.000	M1	1.135	0.064	17.797	0.000
M2	1.336	0.079	16.976	0.000	M2	1.336	0.079	16.976	0.000
M3	0.860	0.084	10.201	0.000	M3	0.860	0.084	10.201	0.000
M4	1.168	0.088	13.305	0.000	M4	1.168	0.088	13.305	0.000
M5	1.001	0.084	11.877	0.000	M5	1.001	0.084	11.877	0.000
M6	1.161	0.080	14.488	0.000	M6	1.161	0.080	14.488	0.000
M7	0.766	0.088	8.732	0.000	M7	0.766	0.088	8.732	0.000
M8	1.144	0.084	13.581	0.000	M8	1.144	0.084	13.581	0.000
M9	0.622	0.073	8.528	0.000	M9	0.622	0.073	8.528	0.000
M1 WITH (= to correlation of .27)					M1 WITH (= to correlation of .46)				
M2	0.485	0.129	3.746	0.000	M2	0.829	0.121	6.883	0.000
Means					Means				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	0.000	0.000	999.000	999.000
Intercepts					Intercepts				
M1	4.176	0.060	69.330	0.000	M1	4.176	0.060	69.330	0.000
M2	3.702	0.074	50.313	0.000	M2	3.702	0.074	50.313	0.000
M3	1.845	0.077	24.121	0.000	M3	1.845	0.077	24.121	0.000
M4	3.473	0.081	42.797	0.000	M4	3.473	0.081	42.797	0.000
M5	2.245	0.077	29.048	0.000	M5	2.245	0.077	29.048	0.000
M6	3.808	0.075	50.564	0.000	M6	3.808	0.075	50.564	0.000
M7	3.842	0.104	37.098	0.000	M7	3.448	0.115	29.880	0.000
M8	3.556	0.079	45.035	0.000	M8	3.556	0.079	45.035	0.000
M9	1.232	0.065	18.878	0.000	M9	1.232	0.065	18.878	0.000
Variances					Variances				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	1.000	0.000	999.000	999.000
Residual Variances					Residual Variances				
M1	1.447	0.111	13.092	0.000	M1	1.447	0.111	13.092	0.000
M2	2.295	0.167	13.746	0.000	M2	2.295	0.167	13.746	0.000
M3	3.649	0.202	18.087	0.000	M3	3.649	0.202	18.087	0.000
M4	3.576	0.213	16.825	0.000	M4	3.576	0.213	16.825	0.000
M5	3.478	0.199	17.502	0.000	M5	3.478	0.199	17.502	0.000
M6	2.906	0.177	16.395	0.000	M6	2.906	0.177	16.395	0.000
M7	3.654	0.279	13.089	0.000	M7	4.625	0.351	13.192	0.000
M8	3.368	0.198	16.986	0.000	M8	3.368	0.198	16.986	0.000
M9	2.807	0.152	18.486	0.000	M9	2.807	0.152	18.486	0.000

Summary of Multiple Group Invariance Model Comparisons (from Excel workbook):

Note: It is your job to keep track of whether chi-square should go up or down!
These formulas work with absolute values.

Model	Model Chi-Square	Model DF	Abs Value Chi Diff	Abs DF Diff	p Value
Configural Model	98.911	52			
Metric Invariance (Loadings) vs. Configural	102.839	60	3.928	8	0.8635604
Scalar Invariance (Intercepts) vs. Metric	115.309	68	12.470	8	0.1314332
Scalar without Intercept 7 vs. Previous Scalar	109.216	67	6.093	1	0.0135718
vs. Previous Metric			6.377	7	0.4964817
Residual Invariance (without 7) vs. Scalar (without 7)	114.059	75	4.843	8	0.7742172
Res Covariance Invariance vs. Residual Invariance	123.351	76	9.292	1	0.0023016
Factor Variance Invariance vs. Residual Invariance	114.904	76	0.845	1	0.3579707
Factor Mean Invariance vs. Factor Variance Invariance	116.143	77	1.239	1	0.2656640