

**Appendix for the paper “A second-order longitudinal model for binary outcomes: Item response theory versus structural equation modeling”**

**Appendix A: Mplus code for the different-anchor design (FIML)**

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TITLE: Case 1 Repetition 1 Method ml
DATA: FILE IS
S: /Resp_C1_001.dat;

VARIABLE: NAMES ARE ti0_it1-ti0_it20
           ti1_it1-ti1_it20
           ti2_it1-ti2_it20
           ti3_it1-ti3_it20;
CATEGORICAL ARE ti0_it1-ti0_it20
                ti1_it1-ti1_it20
                ti2_it1-ti2_it20
                ti3_it1-ti3_it20;

ANALYSIS: ESTIMATOR IS ML;
          LINK IS LOGIT;
          INTEGRATION = MONTECARLO;
          MITERATIONS = 1000;

MODEL:
Skill0 BY ti0_it1* ti0_it2@1.81254012067802 ti0_it3@2.30078000575304 ti0_it4 ti0_it5
ti0_it6 ti0_it7 ti0_it8 ti0_it9 ti0_it10 ti0_it11 ti0_it12 ti0_it13 ti0_it14 ti0_it15
ti0_it16 ti0_it17@1.83317077136599 ti0_it18@2.08360707527027 ti0_it19 ti0_it20
;
Skill1 BY ti1_it1* ti1_it2 ti1_it3 ti1_it4 ti1_it5 ti1_it6 ti1_it7 ti1_it8
ti1_it9@2.49045630614273 ti1_it10@2.08368625980802 ti1_it11 ti1_it12
ti1_it13@2.17745299567468 ti1_it14 ti1_it15@2.42334195529111 ti1_it16 ti1_it17
ti1_it18 ti1_it19 ti1_it20
;
Skill2 BY ti2_it1@2.23466944717802 ti2_it2 ti2_it3 ti2_it4@1.82100854394957 ti2_it5
ti2_it6 ti2_it7@1.96784704830498 ti2_it8 ti2_it9 ti2_it10 ti2_it11@1.70862185815349
ti2_it12 ti2_it13 ti2_it14 ti2_it15 ti2_it16 ti2_it17 ti2_it18 ti2_it19 ti2_it20
;
Skill3 BY ti3_it1* ti3_it2 ti3_it3 ti3_it4@1.67110731289722 ti3_it5 ti3_it6
ti3_it7@1.66099588759243 ti3_it8 ti3_it9 ti3_it10 ti3_it11 ti3_it12 ti3_it13
ti3_it14@2.36916350713 ti3_it15 ti3_it16 ti3_it17@2.18612527404912 ti3_it18 ti3_it19
ti3_it20
;

int slp | skill0@0 skill1@1 skill2@2 skill3@3 ;
[int*0];
[slp*0.25];
int*.1 (vint);
slp*.1 (vslp);
skill0-skill3*0.01 (vth);
int WITH slp@0;

[ ti0_it2$1@-1.34962811480063 ];
[ ti0_it3$1@-0.824051929179392 ];
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[ ti0_it17$1 @2.83883709538547 ];  
[ ti0_it18$1 @0.530827656181135 ];  
[ ti1_it9$1 @-2.43497322264374 ];  
[ ti1_it10$1 @2.72626742255927 ];  
[ ti1_it13$1 @-2.89971155634642 ];  
[ ti1_it15$1 @2.96707642492422 ];  
[ ti2_it1$1 @-3.44250862271768 ];  
[ ti2_it4$1 @-3.29835364575754 ];  
[ ti2_it7$1 @-2.11890653942674 ];  
[ ti2_it11$1 @-0.548602057664192 ];  
[ ti3_it4$1 @-1.798049880791 ];  
[ ti3_it7$1 @0.62174659671742 ];  
[ ti3_it14$1 @-2.07615074965595 ];  
[ ti3_it17$1 @-2.26960799891969 ];
```

MODEL CONSTRAINT:

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vth > 0; ! residual variance of theta  
vslp > 0; ! variance of the slope  
vint > 0; ! variance of the intercept
```

OUTPUT: TECH1, TECH4, TECH10;  
NOCHISQUARE; ! Needed to make the runtime more reasonable for WLSMV estimator.

## Appendix B: *Mplus* code for the same-anchor design (FIML)

TITLE: Case 1 Repetition 1 Method ml  
DATA: FILE IS  
Resp\_C1\_001.dat;

VARIABLE: NAMES ARE ti0\_it1-ti0\_it20  
ti1\_it1-ti1\_it20  
ti2\_it1-ti2\_it20  
ti3\_it1-ti3\_it20;

CATEGORICAL ARE ti0\_it1-ti0\_it20  
ti1\_it1-ti1\_it20  
ti2\_it1-ti2\_it20  
ti3\_it1-ti3\_it20;

ANALYSIS: ESTIMATOR IS ML;  
LINK IS LOGIT;  
INTEGRATION = MONTECARLO(2000);  
MITERATIONS = 1000;

MODEL:

Skill0 BY ti0\_it1\* ti0\_it2 ti0\_it3 ti0\_it4 ti0\_it5 ti0\_it6@1.70164578035474  
ti0\_it7@1.95453773462214 ti0\_it8 ti0\_it9 ti0\_it10 ti0\_it11 ti0\_it12@2.46587414829992  
ti0\_it13 ti0\_it14 ti0\_it15 ti0\_it16@1.65321755036712 ti0\_it17 ti0\_it18 ti0\_it19 ti0\_it20  
;  
Skill1 BY ti1\_it1\* ti1\_it2 ti1\_it3 ti1\_it4 ti1\_it5 ti1\_it6@1.70164578035474  
ti1\_it7@1.95453773462214 ti1\_it8 ti1\_it9 ti1\_it10 ti1\_it11 ti1\_it12@2.46587414829992  
ti1\_it13 ti1\_it14 ti1\_it15 ti1\_it16@1.65321755036712 ti1\_it17 ti1\_it18 ti1\_it19 ti1\_it20  
;  
Skill2 BY ti2\_it1\* ti2\_it2 ti2\_it3 ti2\_it4 ti2\_it5 ti2\_it6@1.70164578035474  
ti2\_it7@1.95453773462214 ti2\_it8 ti2\_it9 ti2\_it10 ti2\_it11 ti2\_it12@2.46587414829992  
ti2\_it13 ti2\_it14 ti2\_it15 ti2\_it16@1.65321755036712 ti2\_it17 ti2\_it18 ti2\_it19 ti2\_it20  
;  
Skill3 BY ti3\_it1\* ti3\_it2 ti3\_it3 ti3\_it4 ti3\_it5 ti3\_it6@1.70164578035474  
ti3\_it7@1.95453773462214 ti3\_it8 ti3\_it9 ti3\_it10 ti3\_it11 ti3\_it12@2.46587414829992  
ti3\_it13 ti3\_it14 ti3\_it15 ti3\_it16@1.65321755036712 ti3\_it17 ti3\_it18 ti3\_it19 ti3\_it20  
;  
TLt\_6 BY ti0\_it6\* ti1\_it6 ti2\_it6 ti3\_it6 (6);  
TLt\_7 BY ti0\_it7\* ti1\_it7 ti2\_it7 ti3\_it7 (7);  
TLt\_12 BY ti0\_it12\* ti1\_it12 ti2\_it12 ti3\_it12 (12);  
TLt\_16 BY ti0\_it16\* ti1\_it16 ti2\_it16 ti3\_it16 (16);

int slp | skill0@0 skill1@1 skill2@2 skill3@3 ;  
[int\*0];  
[slp\*0.25];  
int\*.1 (vint);  
slp\*.1 (vslp);  
skill0-skill3\*0.01 (vth);  
int WITH slp@0;

TLt\_6 WITH TLt\_7@0;

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TLt_6 WITH TLt_12@0;
TLt_6 WITH TLt_16@0;
TLt_7 WITH TLt_12@0;
TLt_7 WITH TLt_16@0;
TLt_12 WITH TLt_16@0;
int WITH TLt_6@0;
int WITH TLt_7@0;
int WITH TLt_12@0;
int WITH TLt_16@0;
slp WITH TLt_6@0;
slp WITH TLt_7@0;
slp WITH TLt_12@0;
slp WITH TLt_16@0;
[ ti0_it6$1 @-0.038965483884687 ];
[ ti0_it7$1 @-0.261822189868949 ];
[ ti0_it12$1 @-2.67175853634971 ];
[ ti0_it16$1 @-1.7343326365795 ];
[ ti1_it6$1 @-0.038965483884687 ];
[ ti1_it7$1 @-0.261822189868949 ];
[ ti1_it12$1 @-2.67175853634971 ];
[ ti1_it16$1 @-1.7343326365795 ];
[ ti2_it6$1 @-0.038965483884687 ];
[ ti2_it7$1 @-0.261822189868949 ];
[ ti2_it12$1 @-2.67175853634971 ];
[ ti2_it16$1 @-1.7343326365795 ];
[ ti3_it6$1 @-0.038965483884687 ];
[ ti3_it7$1 @-0.261822189868949 ];
[ ti3_it12$1 @-2.67175853634971 ];
[ ti3_it16$1 @-1.7343326365795 ];
[TLt_6@0]; TLt_6@1;
[TLt_7@0]; TLt_7@1;
[TLt_12@0]; TLt_12@1;
[TLt_16@0]; TLt_16@1;
MODEL CONSTRAINT:
vth > 0; ! residual variance of theta
vslp > 0; ! variance of the slope
vint > 0; ! variance of the intercept
OUTPUT: TECH1, TECH4, TECH10;
        NOCHISQUARE;
SAVEDATA: FILE IS
FS_C1ml001.dat ;
        SAVE = FSCORES;

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