1. Tables

HW1

HW2

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | s |  |  |  |
| a | 50964.1 | 147 | 51258.1 | 51605.8 | 52267.6 | 52414.6 |  | 76.95 | - | - |
| b | 48061.8 | 148 | 48357.8 | 48707.8 | 49374.2 | 49522.2 |  | 51.12 | - | - |
| c | 51489.0 | 3 | 51495.0 | 51498.7 | 51504.0 | 51507.0 | 20.94 | 78.58 |  |  |
| d | 51489.0 | 3 | 51495.0 | 51498.7 | 51504.0 | 51507.0 | 20.94 | 78.58 |  |  |
| e | 48482.4 | 4 | 48490.4 | 48495.2 | 48502.3 | 48506.3 | 6.01 | 52.23 | .41 | .68 |
| f | 48482.4 | 4 | 48490.4 | 48495.2 | 48502.3 | 48506.3 | 6.01 | 52.23 | .41 | .68 |
| g | 48646.8 | 4 | 48654.8 | 48659.6 | 48666.7 | 48670.7 | 21.67 | 52.20 | .26 | .00 |
| h | 51267.2 | 4 | 51275.2 | 51280.1 | 51287.2 | 51291.2 | 3.05 | 78.62 | .18 | .78 |
| i | 48426.4 | 5 | 48436.4 | 48442.5 | 48451.3 | 48456.3 | 3.71 | 52.23 | .43 | .78 |
| j | 48363.7 | 7 | 48377.7 | 48386.2 | 48398.6 | 48405.6 | 3.75 | 51.75 | .44 | .78 |
| k | 48359.0 | 10 | 48379.0 | 48391.1 | 48408.8 | 48418.8 | 3.63 | 51.75 | .44 | .78 |
| l | 48363.5 | 8 | 48379.5 | 48389.2 | 48403.4 | 48411.4 | 3.75 | 51.75 | .44 | .78 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | s |  |  |  |
| j | 48363.7 | 7 | 48377.7 | 48386.2 | 48398.6 | 48405.6 | 3.75 | 51.75 | .44 | .78 |
| n | 48347.2 | 9 | 48365.2 | 48376.1 | 48392.0 | 48401.0 | 3.67 | 51.65 | .44 | .78 |
| o | 48338.6 | 12 | 48362.6 | 48377.2 | 48398.4 | 48410.4 | 3.38 | 51.65 | .45 | .80 |
| p | 48306.8 | 14 | 48334.8 | 48351.8 | 48376.6 | 48390.6 | 3.44  0.06  0.01 | 50.90 | .45 | .79 |
| q | 48334.1 | 14 | 48362.1 | 48379.0 | 48403.8 | 48417.8 | 3.69  -0.31  0.17 | 51.43 | .45 | .78 |
| r | 48337.7 | 14 | 48365.7 | 48382.7 | 48407.5 | 48421.5 | 4.06  -0.19  0.02 | 51.64 | .44 | .77 |
| s | 48255.4 | 18 | 48291.4 | 48313.2 | 48345.1 | 48363.1 | 3.40  0.04  0.002 | 50.90 | .45 | .80 |
| t | 48255.1 | 19 | 48293.1 | 48316.1 | 48349.8 | 48368.8 | 3.40  0.04  0.0023 | 50.90 | .45 | .80 |
| u | 48247.3 | 21 | 48289.3 | 48314.74 | 48351.9 | 48372.9 | 3.17  0.10  0.0023  -0.16  -0.02  0.13 | 50.72 | .46 | .81 |

(a)

There is no “unique best” model among random intercept models. Model (o) from HW2 has the smallest AIC (48362.6), but in terms of HQIC, BIC, and CAIC, model (n) from HW2 is the “best” model, because it has the smallest HQIC, BIC, and CAIC.

(b)

Taking all models into consideration, model (s) has the smallest AIC (48291.4), HQIC (48313.2), BIC (48345.1), and CAIC (48363.1).

(c)

Harmonic mean:

x̄+ = 146/3.627=40.25

(d)

Base on R^2 values, mode (u) from HW2 should be the best model, because it has the largest R^2 values (.46 and .81). This is not the same when we use information criterion, based on which model (s) is the best model.

(e)

R21: Compared with the null model, when predictors such as group centered math, gender, grade, hours watching TV, community type are included, the proportional reduction in squared prediction errors of Yij is 45%.

R22: Compared with the null model, Compared with the null model, when predictors such as group centered math, gender, grade, hours watching TV, community type are included, the proportional reduction in squared prediction errors of group means Y-barj is 80%.



H0 :  == 0;

H1: Not H0.

= 48261.3-48255.4 =5.9

Mixture of Chi-square1 and Chi-square2 is 0.01, indicating that we can reject H0, and thus a random slope is necessary.

1. The robust standard errors of predictors are not very different from those for the model based ones. The only exceptions are that the model based S.E.(2.0471) for isolated community is a lot larger than the robust S.E. (0.2662), and that the model based S.E. (0.1053) for the cross-level interactions between grpCmath and rural community is a lot larger than the robust S.E. (0.014)

The significance tests give almost exactly the same results, except for the cross-level interactions of grpCmath\*community (isolated and rural) are not significant for model based, but significant for robust.

S.E. of covariance parameters are not affected under the robust condition.



1. The tables below are obtained using model based S.E.

(a) Type of community

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Label | Num df | Den df | F-value | p-value |
| Urban / Sub | 1 | 130 | 0.00 | 0.95 |
| Iso vs. sub/urban | 1 | 108 | 3.94 | 0.0497 |
| Rural vs. sub/urban | 1 | 144 | 3.96 | 0.0486 |
| Iso vs. Rural | 1 | 109 | 2.20 | 0.1411 |

Recode: type of community was recoded into 3 levels instead of 4, being iso, rural and urban/sub.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | | No. | AIC | HQIC | BIC | CAIC | s |  |  |  |
| 4a | 48262.2 | 13 | | 48288.2 | 48304.0 | 48327.0 | 48340.0 |  |  |  |  |

(b) Hours watching TV or videos

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Label | Num df | Den df | F-value | p-value |
| All<4 hrs same | 3 | 7021 | 2.03 | 0.1071 |
| Some vs. 4+ hrs | 1 | 7039 | 12.73 | 0.0004 |

Recode: hours watching TV was recoded into 0 if smaller or equal to 4 hrs, and 1 if larger than 4 hrs.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | s |  |  |  |
| 4b | 48248.8 | 13 | 48274.8 | 48290.6 | 48313.6 | 48326 |  |  |  |  |

(c) Hours computer games

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Label | Num df | Den df | F-value | p-value |
| All<4 hrs same | 3 | 7033 | 0.98 | 0.4013 |
| Some vs. 4+ hrs | 1 | 6997 | 14.95 | 0.00 |

Recode: hours playing computer games was recoded into 0 if smaller or equal to 4 hrs, and 1 if larger than 4 hrs.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | s |  |  |  |
| 4c | 48240.0 | 13 | 48266.0 | 48281.7 | 48304.7 | 48317.7 |  |  |  |  |

1. (1) Remove cross-level interaction with type of community

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | df | lambda | p-value | Decision |
| 5.1 | 48260.0 | 15 | 48290.0 | 48308.2 | 48334.8 | 48349.8 | 3 | 4.6 | .33 | Drop ok |

(2) Re-code community type into 2 levels

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | df | lambda | p-value | Decision |
| 5.2 | 48262.2 | 13 | 48288.2 | 48304.0 | 48327.0 | 48340.0 | 2 | 2.2 | .33 | Recoding ok |

(3) Re-code TV into 2 levels

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | df | lambda | p-value | Decision |
| 5.3 | 48248.8 | 13 | 48274.8 | 48290.6 | 48313.6 | 48326 | 3 | 6.0 | .11 | Recoding ok |

(4) Re-code computer games into 2 levels

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | df | lambda | p-value | Decision |
| 5.4 | 48240.0 | 13 | 48266.0 | 48281.7 | 48304.7 | 48317.7 | 3 | 3.0 | .39 | Recoding ok |

(5) Remove the random slope

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | -2LnLike | No. | AIC | HQIC | BIC | CAIC | df | lambda | p-value | Decision |
| 5.5 | 48246.2 | 11 | 48268.2 | 48281.5 | 48301.0 | 48312.0 | 2 | 6.2 | .03 | Keep it |

**Model 5.4 would be an ideal one, because it has rather satisfying information criterion, and all fixed effects are significant. Plus the model is parsimonious.**

1. H0:  == 0; H1: Not H0.

 = 48246.2-48240.0=6.2

The mixture of Chi-square 1 and Chi-square 2 is approximately 0.028, so we can reject the null hypothesis and keep the random slope in our model.





HLM:

Level 1:



Level 2:



Where



LMM:



MM:

Scienceij ~ 

Where



and 11.26+0.09+0.00004

**Interpretation:**  
Science score is expected to be 1.3 points higher for boys, 0.86 points higher for 4th grades, 0.84 points higher for students watching TV for less than 4 hours, 1.52 points higher for students playing computer games for less than 4 hours, and 1.08 points higher when a student comes from a school that is in either rural or isolated areas.

For every 1 point increase of a student’s math score relative to peers, the science score is expected to increase, but it’s constrained by school’s mean math score, which means that if a student is from a school with high mean math score, then the student’s performance relative to peers is less important, compared with a student coming from a school with low math mean score.