1. **Models Equations**

**(n)**

**HM:**

**Level 1:**



Where  and are independent.

**Level 2:**



Where i.i.d. and are independent of 

**LMM:**

****

**MM:**

****

Where



**(o)**

= 1 if isolated; = 0 if not;

= 1 if rural; = 0 if not;

 = 1 if suburb; = 0 if not.

**HM:**

**Level 1:**



Where  and are independent

**Level 2:**



Where  i.i.d. and are independent of 

**LMM:**

****

**MM:**

****

Where



**(p)**

**HM:**

**Level 1:**

****

Where  and are independent.

**Level 2:**



Where  i.i.d. and are independent of 

**LMM:**



**MM:**



Where





**(q)**

**HM:**

**Level 1:**

****

Where  and are independent.

**Level 2:**



Where  i.i.d. and are independent of 

**LMM:**



**MM:**



Where





**(r)**

**HM:**

**Level 1:**

****

Where  and are independent.

**Level 2:**



Where  i.i.d. and are independent of .

**LMM:**

****

**MM:**

****

Where





**(s)**

**HM:**

**Level 1:**

****

Where  and are independent.

**Level 2:**

****

Where  i.i.d. and are independent of.

**LMM:**



**MM:**

****

Where





1. **Summary Table**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Fixed Effects | | | Random Effects | | | | Fit Statistics | |
|  |  |  |  |  | Between | | Within | |  | |
| M | No.of estimated parameters | Names | ’s | SE |  | SE |  | SE | -2 loglike | *AIC* |
| j | 7 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM | 14.05  .55  -.093  0  1.11  0  .90 | 5.97  .01  .20  .  .17  .  .04 | 3.75 | .59 | 51.75 | .88 | 48363.7 | 48377.7 |
| n | 9 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM  hours\_TV  hours\_C\_G | 12.33  .55  -.92  0  1.21  0  .89  -.09  -.28 | 5.99  .01  .20  .  .17  .  .04  .07  .08 | 3.67 | .58 | 51.65 | .88 | 48347.2 | 48365.2 |
| o | 12 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM  hours\_TV  hours\_C\_G  type\_iso  type\_rur  type\_sub  type\_urb | 15.93  .55  -.93  0  1.21  0  .89  -.09  -.28  4.32  1.08  .09  0 | 5.86  .01  .20  .  .17  .  .04  .07  .08  2.04  .51  .40  . | 3.38 | .55 | 51.65 | .88 | 48338.6 | 48362.6 |
| p | 14 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM  hours\_TV  hours\_C\_G  type\_iso  type\_rur  type\_sub  type\_urb | 8.74  .56  -.90  0  1.26  0  .94  -.08  -.27  3.95  .92  -.02  0 | 5.78  .01  .20  .  .17  .  .04  .07  .08  2.00  .50  .40  . | =3.44 SE=.56  =.06 SE=.03  =.01 SE=.0026  =50.90 SE=.87 | | | | 48306.8 | 48334.8 |
| q | 14 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM  hours\_TV  hours\_C\_G  type\_iso  type\_rur  type\_sub  type\_urb | 15.02  .55  -.92  0  1.20  0  .90  -.09  -.28  4.13  1.08  .03  0 | 5.81  .01  .20  .  .17  .  .04  .08  .08  2.00  .51  .40  . | =3.69 SE=1.50  =-.31 SE=.37  =.17 SE=.11  =51.43 SE=.88 | | | | 48334.1 | 48362.1 |
| r | 14 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM  hours\_TV  hours\_C\_G  type\_iso  type\_rur  type\_sub  type\_urb | 15.56  .55  -.93  0  1.21  0  .89  -.09  -.28  4.30  1.13  .13  0 | 5.82  .01  .20  .  .17  .  .04  .07  .08  2.04  .51  .40  . | =4.06 SE=1.01  =-.19 SE=.27  =.02 SE=.10  =51.64 SE=.88 | | | | 48337.7 | 48365.7 |
| s | 18 | Intercept  grpC  grade\_3  grade\_4  gender\_b  gender\_g  grpM  hours\_TV  hours\_C\_G  type\_iso  type\_rur  type\_sub  type\_urb  grpC\*grpM  grpC\*iso  grpC\*rur  grpC\*sub  grpC\*urb | 15.86  3.30  1.28  0  -.87  0  -.09  -.26  .89  4.33  1.08  .08  0  -.02  .10  .06  .03  0 | 5.86  .35  .17  .  .19  .  .07  .08  .04  2.05  .51  .40  .  .0024  .11  .03  .02  . | =3.40 SE=.55  =.04 SE=.02  =.0022 SE=.0017  =50.90 SE=.87 | | | | 48255.4 | 48291.4 |

1. It appears that we need a random slop e for grpCmath, because it seems that  is rather large (.0091) relative to its standard error (.0026). However, (.1677) and  (.0179) are rather smaller relative to their standard errors (.1102 and .0973 respectively).

Furthermore, the model with a random slope for grpCmath has the smallest AIC (48334.8) among all 3 models, which means the model with a random slope for grpCmath fits the best.

1. GrpMmath helps predict the random slope for grpCmath, because in model (s) and model (t), the cross-level interactions between grpCmath and grpMmath are both significant (p-values<.0001), while none of the interactions between grpCmath and type of community and the interactions between grpCmath and shortages is significant.
2. After fitting the original “my favorite” model, the fixed effect of suburban is not significant (p-value=.93), so I recoded the variable “type\_community”, where =1 if isolated, and =0 if not; =1 if rural and =0 if not. If the school is either suburban or urban, then ==0.

**HM:**

**Level 1:**



Where and are independent.

**Level 2:**



Where  i.i.d. and are independent of.

According to the results, the model can be written out as:



Where



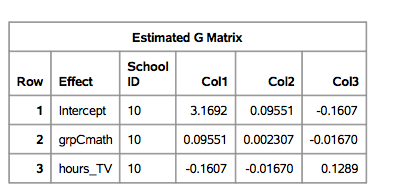


Interpretation:

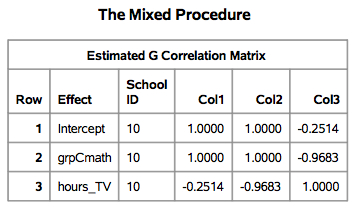
1. Boys who are at 4th grade, spend less time watching TV, have higher math scores than peers, come from schools with higher average math scores, and come from schools in isolated locations tend to have the highest science scores.
2. 4th grades have science scores that are .88 points higher than 3rd grades.
3. Boys have science scores that are 1.21 points higher than girls.
4. For every hour spent watching TV, science scores tend to be .14 points lower.
5. For schools with average math scores that are 1 point higher, students tend to have science scores that are .9 points higher.
6. Science scores of schools in isolated locations are 4 points higher than urban and suburban schools.
7. Science scores of schools in rural locations are .98 points higher than urban and suburban schools.
8. If a student comes from a school with higher average math score, and the student has a math score that is 1 unite higher than that of his or her peers, then the change of the student’s science score would be 3.25. This indicates that the effects of the macro effect (grpMmath) and the micro effect (grpCmath) are heading opposite directions. A student who does better than peers in math coming from a school with lower average math score tend to have higher science score.

**6.** Yes there is a problem that is reported by SAS for model (u).

**NOTE: Estimated G matrix is not positive definite.**



Which is not a good covariance matrix, because (0.09551>) instead of .

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The correlations we get are not very good, because the correlation between intercept and grpCmath is 1.

To conclude, model (u) is not a good model for the data.