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.