

# Review of Multilevel Models So Far

## 1 Graph

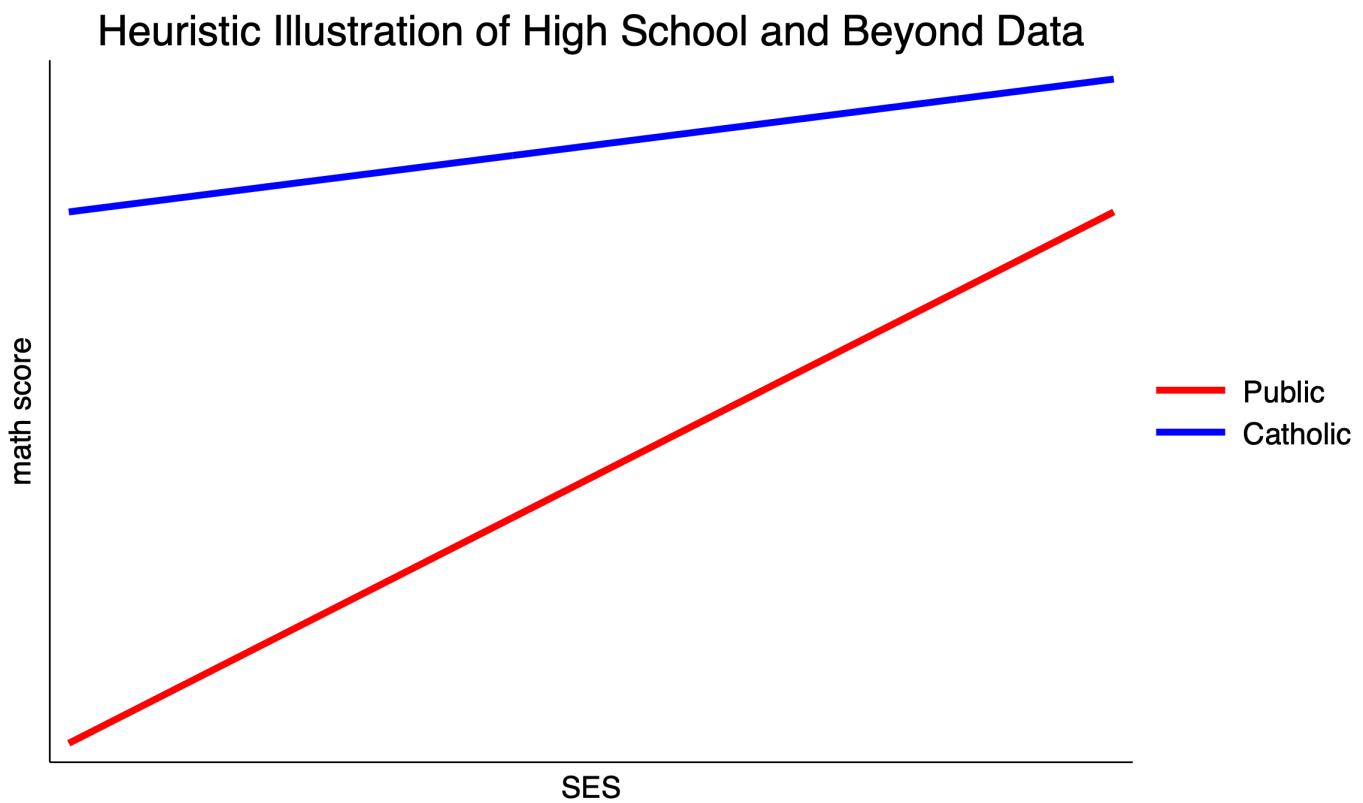


Figure 1: heuristic illustration of HBS data

## 2 Equation in Multiple Equation Format

$$\begin{aligned}y_{ij} &= \beta_{0j} + \beta_{1j}x + e_{ij} \\ \beta_{0j} &= \gamma_{00} + \gamma_{01}\text{sector} + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11}\text{sector} + u_{0j}\end{aligned}\tag{1}$$

💡 Random Effects Are Optional

The random effects in Equation 1 are *optional* in the sense that they may or may not be included. Often only a *random intercept* is included. Inclusion of multiple *random slopes* may lead to non-convergence of the model.

### 3 Intra-Class Correlation Coefficient

$$\text{icc} = \frac{\text{var}(u_{0j})}{\text{var}(u_{0j}) + \text{var}(e_{ij})}$$

### 4 How Many Levels?

For the  $i^{th}$  student in the  $j^{th}$  school in the  $k^{th}$  district.

$$\begin{aligned} y_{ijk} &= \pi_{0jk} + \pi_{1jk}a + e_{ijk} \\ \text{there are } p &\text{ level 1 coefficients} \\ \pi_{pj} &= \beta_{0pk} + \beta_{1pk} + r_{pj} \\ \text{group specific effect for the } j\text{th group} & \\ \text{there are } q &\text{ level 2 coefficients} \\ \beta_{pqk} &= \gamma_{0pq} + \gamma_{1pq}w + u_{pqk} \\ \text{there are } p^*q &\text{ level 3 coefficients} \end{aligned} \tag{2}$$

### 5 A Single Level Equation

Using substitution, we re-write Equation 1.

$$y_{ij} = \gamma_{00} + \gamma_{01}\text{sector} + \gamma_{10}x + \gamma_{11}\text{sector} \times x + e_{ij} + u_{0j} + u_{1j} \times x \tag{3}$$

Let's just call everything a  $\beta$ .

$$y_{ij} = \beta_0 + \beta_1\text{sector} + \beta_2x + \beta_3\text{sector} \times x + e_{ij} + u_{0j} + u_{1j} \times x \tag{4}$$

  $x$  is ses

In the concrete example that I am using  $x$  is ses