

MULTILEVEL ANALYSIS IN R

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1. MODEL

$$\begin{aligned}y_j &= X_j \beta_j + \epsilon_j, \\ \beta_j &= Z_j \gamma + \delta_j.\end{aligned}$$

2. LS1

$$\min \|y_j - X_j \beta_j - \epsilon_j\|^2 + \|\beta_j - Z_j \gamma - \delta_j\|^2$$

with $\epsilon_j \perp X_j$ and $\delta_j \perp Z_j$. Write

$$y_j = X_j b_j + e_j,$$

with $e_j \perp X_j$, and

$$\beta_j = Z_j g_j + d_j,$$

with $d_j \perp Z_j$. Thus

$$\begin{aligned}\min & \|X_j(b_j - \beta_j) - (e_j - \epsilon_j)\|^2 + \|Z_j(g_j - \gamma) - (d_j - \delta_j)\|^2 = \\ & (b_j - \beta_j)' X_j' X_j (b_j - \beta_j) + \|e_j - \epsilon_j\|^2 + (g_j - \gamma)' Z_j' Z_j (g_j - \gamma) + \|d_j - \delta_j\|^2\end{aligned}$$

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3. LS 2

$$\min \|y_j - X_j Z_j \gamma - X_j \delta_j - \epsilon_j\|^2$$

with $\epsilon_j \perp X_j$ and $\delta_j \perp Z_j$.

$$\min \|X_j(b_j - Z_j \gamma - \delta_j) - (e_j - \epsilon_j)\|^2$$

$$\min \|X_j(Z_j(g_j - \gamma) - (d_j - \delta_j)) - (e_j - \epsilon_j)\|^2$$

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