Example II:

$$y = X\beta + Zu_s + e$$

$$E(\underline{e}) = \underline{0}, \quad E(\underline{u_s}) = \underline{0}, \quad E(y) = X\underline{\beta}$$

$$Var(\underline{e}) = R = I \cdot \sigma_e^2$$

$$var(\underline{u_s}) = \begin{bmatrix} var(u_1) & \boxed{cov(u_1,u_4)} & cov(u_1,u_5) \\ cov(u_4,u_1) & var(u_4) & cov(u_4,u_5) \\ cov(u_5,u_1) & cov(u_5,u_4) & var(u_5) \end{bmatrix} = G$$

$\rightarrow \neq 0$ because sire1 is the father of 4

$$u_s = \begin{bmatrix} u_1 \\ u_4 \\ u_5 \end{bmatrix}$$

$$= \begin{bmatrix} \sigma_{us}^2 & 1/2\,\sigma_u^2 & 1/4\,\sigma_u^2 \\ 1/2\,\sigma_u^2 & \sigma_{us}^2 & 1/2\,\sigma_u^2 \\ 1/4\,\sigma_u^2 & 1/2\,\sigma_u^2 & \sigma_{us}^2 \end{bmatrix}$$

$$u_i = 1/2\,u_s + \boxed{1/2\,u_d + m_i} \rightarrow m_4^*$$

For sire model: $u_4 = 1/2\,u_1 + m_4^*$

$$cov(u_1,u_4) = cov(u_1, 1/2\,u_1 + m_4^*)$$

$$= cov(u_1, 1/2\,u_1) + \overbrace{cov(u_1, m_4^*)}^{=0}$$

$$= 1/2\,cov(u_1,u_1) = 1/2\,\sigma_u^2$$