VARIATIONAL APPROXIMATION FOR "FINE-MAPPING" MODEL

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First, we define the probabilistic model:

$$\begin{aligned} p(y \mid \mathbf{X}, \beta, \sigma^2) &= N(y \mid \mathbf{X}\beta_1 + \cdots + \mathbf{X}\beta_K, \sigma^2 I) \\ p(\beta_{jk} \mid \gamma_k = j) &= N(0, \sigma^2\sigma_a^2) \\ p(\beta_{jk} \mid \gamma_k \neq j) &= \delta_0 \\ p(\gamma_k = j) &= \pi_j. \end{aligned}$$

Next, we define the variational approximation:

The variational lower bound $F(\theta, \phi) \equiv \int\int q(\beta, \gamma; \phi) \log \left\{ p(y, \beta, \gamma \mid \mathbf{X}, \theta) / q(\beta, \gamma; \phi) \right\} d\beta \, d\gamma$ is derived to be

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