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We observe $X_i, Z_1, \dots, Z_J$, and d_i

The likelihood of choosing j and J respectively is:

$$P_{ij} = \frac{\exp(u_{ij} - u_{iJ})}{1 + \sum_{k=1}^{J-1} \exp(u_{ik} - u_{iJ})}$$

$$P_{iJ} = \frac{1}{1 + \sum_{k=1}^{J-1} \exp(u_{ik} - u_{iJ})}$$

The log likelihood function we maximize is:

$$\ell(X, Z, d; \beta, \gamma) = \sum_{i=1}^{N} \left[\sum_{j=1}^{J-1} (d_{ij} = 1)(u_{ij} - u_{iJ}) \right] - \log \left(1 + \sum_{k=1}^{J-1} \exp(u_{ik} - u_{iJ}) \right)$$

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