Bivariate Ordered Probit
Ordered Probability Models

- Unobserved variable is typically specified as a linear function for each observation (n subscripting omitted), such that

\[ z = \beta X + \varepsilon, \]

- where \( X \) is a vector of explanatory variables determining the discrete ordering for observation \( n \), \( \beta \) is a vector of estimable parameters, and \( \varepsilon \) is a random disturbance.
Using this equation, observed ordinal data, $y$, for each observation are defined as,

$$
\begin{align*}
y &= 1 \quad \text{if } z \leq \mu_0 \\
y &= 2 \quad \text{if } \mu_0 < z \leq \mu_1 \\
y &= 3 \quad \text{if } \mu_1 < z \leq \mu_2 \\
y &= \ldots \\
y &= I \quad \text{if } z \geq \mu_{I-1} ,
\end{align*}
$$

where $\mu$ are estimable parameters (referred to as thresholds) that define $y$, which corresponds to integer ordering, and $I$ is the highest integer ordered response.
For the Bivariate case we have:

\[ z_{i1} = \beta_1 X_{i1} + \varepsilon_{i1}, \]

\[ z_{i2} = \beta_2 X_{i2} + \varepsilon_{i2}, \]

And we now take into account the facts that these equations are linked by:

\[ \rho = \text{Cor}(\varepsilon_{i1}, \varepsilon_{i2}) \]

This is equivalent to a SURE model for non-continuous data.
Limdep commands are more involved:

1. Estimate two single equation models and store estimation results

2. Use single equation results to estimate a joint model and $\rho$
Assignment 4 (based on Example 14.1)

• A survey of 279 commuters conducted in the Seattle metropolitan area.

• The survey's intent was to gather information on commuters' opinions of high-occupancy vehicle (HOV) lanes (lanes that are restricted for use by vehicles with 2 or more occupants).

• Opinion questions have ordered opinion responses:

  strongly disagree, disagree, neutral, agree, agree strongly
Questions we will address:

1. Existing HOV lanes are being adequately used:
   0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

2. HOV lanes should be open to all traffic:
   0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

With these questions we expect:

\[ \rho = \text{Cor}(\varepsilon_{i1}, \varepsilon_{i2}) \text{ will be negative} \]
Limdep estimation procedure:

1. Existing HOV lanes are being adequately used (x28):

   oprobit;lhs=x28;rhs=one,….$
   matrix;b1=b;mu1=mu$

2. HOV lanes should be open to all traffic (x29):

   oprobit;lhs=x29;rhs=one,….$
   matrix;b2=b;mu2=mu$
3. Estimate the bivariate model:

oprobit; lhs=x28,x29
; rh1=one,dalone,x8,oldmen,college,x37
; rh2=one,dalone,x8,oldmen,college,x37
; start=b1,mu1,b2,mu2,0$

Here the “start” command has beta’s and mu’s from univariate models, and the “0” is the initial correlation coefficient, ρ
Assignment #4:

- Says to model X28 and X29

- **BUT:** You can experiment with any dual combination of:
  
  X27; X28; X29; X30; X31

- Also can consider recoding X27; X28; X28; X30; X31 from 5 responses: 0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

- To 3: 0 if strongly disagree or if disagree, 1 if neutral, 3 if agree or agree strongly
X27  HOV lanes save all commuters time: 0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

X28  Existing HOV lanes are being adequately used: 0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

X29  HOV lanes should be open to all traffic: 0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

X30  Converting some regular lanes to HOV lanes is a good idea: 0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly

X31  Converting some regular lanes to HOV lanes is a good idea only if it is done before traffic congestion becomes serious: 0 if strongly disagree, 1 if disagree, 2 if neutral, 3 if agree, 4 if agree strongly