Multinomial Logit

Simulated Data

```
set obs 500
set seed 12345
g x1=(runiform()>0.7)
g u=rnormal(0,1)
g i2=-0.7+0.5*x1+u
g i3=-0.5-0.7*x1+u
g e2=exp(i2)
g e3=exp(i3)
g p1=1/(1+e2+e3)
g p2=e2/(1+e2+e3)
g p3=e3/(1+e2+e3)
g y=1 if p1==max(p1,p2,p3)
replace y=2 if p2==max(p1,p2,p3)
replace y=3 if p3==max(p1,p2,p3)
```

```
. mlogit y x1, nolog

Multinomial logistic regression                   Number of obs   =        500
                                                  LR chi2(2)      =      45.34
                                                  Prob > chi2     =     0.0000
Log likelihood = -501.34448                       Pseudo R2       =     0.0433

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |  (base outcome)
-------------+----------------------------------------------------------------
2            |
          x1 |   1.050613   .2434391     4.32   0.000     .5734812    1.527745
       _cons |  -1.188763   .1568918    -7.58   0.000    -1.496266    -.881261
-------------+----------------------------------------------------------------
3            |
          x1 |  -.8923277   .2813813    -3.17   0.002    -1.443825   -.3408305
       _cons |  -.2390744   .1142208    -2.09   0.036    -.4629431   -.0152057
------------------------------------------------------------------------------

. est store m1

. tab x1

         x1 |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |        364       72.80       72.80
          1 |        136       27.20      100.00
------------+-----------------------------------
      Total |        500      100.00
```

From the estimated result:

$$P(y=2|x_1=0)=\exp(-1.1888)=0.3046$$

$$P(y=2|x_1=1)=\exp(-1.1888+1.0506)=0.8710$$

$$rrr=\frac{P(y=2|x_1=1)}{P(y=2|x_1=0)}=\frac{0.8710}{0.3046}=2.8594=\exp(1.0506)$$

```
. mlogit y x1, rrr nolog

Multinomial logistic regression                   Number of obs     =        500
                                                  LR chi2(2)        =      45.34
                                                  Prob > chi2       =     0.0000
Log likelihood = -501.34448                       Pseudo R2         =     0.0433

------------------------------------------------------------------------------
           y |        RRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |  (base outcome)
-------------+----------------------------------------------------------------
2            |
          x1 |   2.859404   .6960907     4.32   0.000     1.774433    4.607774
       _cons |   .3045977   .0477889    -7.58   0.000     .2239649    .4142602
-------------+----------------------------------------------------------------
3            |
          x1 |    .409701   .1152822    -3.17   0.002     .2360233    .7111794
       _cons |   .7873563   .0899325    -2.09   0.036     .6294285    .9849093
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(1))

Average marginal effects                          Number of obs     =        500
Model VCE    : OIM

Expression   : Pr(y==1), predict(outcome(1))
dy/dx w.r.t. : x1

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    .028185   .0521529     0.54   0.589    -.0740328    .1304029
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(2))

Average marginal effects                          Number of obs     =        500
Model VCE    : OIM

Expression   : Pr(y==2), predict(outcome(2))
dy/dx w.r.t. : x1

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .2133354   .0317421     6.72   0.000     .1511221    .2755488
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(3))

Average marginal effects                          Number of obs     =        500
Model VCE    : OIM

Expression   : Pr(y==3), predict(outcome(3))
dy/dx w.r.t. : x1

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.2415204   .0502526    -4.81   0.000    -.3400137   -.1430272
------------------------------------------------------------------------------

. mlogit y x1 if y!=3, nolog

Multinomial logistic regression                   Number of obs     =        343
                                                  LR chi2(1)        =      18.79
                                                  Prob > chi2       =     0.0000
Log likelihood = -203.49155                       Pseudo R2         =     0.0441

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |  (base outcome)
-------------+----------------------------------------------------------------
2            |
          x1 |   1.050613   .2434391     4.32   0.000     .5734811    1.527745
       _cons |  -1.188763   .1568918    -7.58   0.000    -1.496266    -.881261
------------------------------------------------------------------------------
```

```
. est store m2

. hausman m1 m2, alleqs constant
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m1           m2         Difference          S.E.
-------------+----------------------------------------------------------------
          x1 |    1.050613     1.050613         1.91e-08         .000016
       _cons |   -1.188763    -1.188763        -1.94e-08         .000016
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.00
                Prob>chi2 =      1.0000
```

Multinomial Logit & Ordered Probit Models
Pecking Order Model

Objectives

To test whether pecking order holds for Thai firms after financial crisis.
The study applied:
- Multinomial Logit to measure determinants of financing choices.
- Ordered Probit Regressions to determine which financing hierarchy fits the data best.

Multinomial Logit Model

Dependent variable has more than two choices.

$$p_{ij} = \frac{e^{x_i'\beta_j}}{\sum_{h=1}^{3} e^{x_i'\beta_h}} = \frac{e^{x_i'\beta_j}}{1+\sum_{h=2}^{3} e^{x_i'\beta_h}}$$

Ordered Probit Model

In case that choices are ordered, ordered probit model can be applied.

$$y_i^* = x_i'\beta + \varepsilon_i, \quad E(\varepsilon_i) = 0$$

$$\begin{aligned} y_i &= 1 \quad if \; -\infty < y_i^* \le c_1, \\ y_i &= 2 \quad if \; c_1 < y_i^* \le c_2, \\ y_i &= 3 \quad if \; c_2 < y_i^* \le \infty \end{aligned}$$

where: c_i = Threshold value and $i=1,2$

Data

Dependent Variables--Financing Choices (y)
1 = Internal Finance
2 = Long- term debt and bond
3 = Share issues

Independent Variables (x_k):
x_1 = Liquidity
x_2 = Profitability
x_3 = Interest Payments
x_4 = Log of firm size

Multinomial Logit Model

```
. mlogit y x1 x2 x3 x4, nolog

Multinomial logistic regression                   Number of obs     =        344
                                                  LR chi2(8)        =     118.14
                                                  Prob > chi2       =     0.0000
Log likelihood = -169.69647                       Pseudo R2         =     0.2582

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |  (base outcome)
-------------+----------------------------------------------------------------
2            |
          x1 |  -11.38892   1.553865    -7.33   0.000    -14.43444    -8.3434
          x2 |   2.034482   1.693449     1.20   0.230    -1.284617   5.353581
          x3 |  -.4413597   .2234444    -1.98   0.048    -.8793026  -.0034168
          x4 |   21.82959   9.663678     2.26   0.024     2.889132   40.77005
       _cons |   .9764104   .3125365     3.12   0.002     .3638501   1.588971
-------------+----------------------------------------------------------------
3            |
          x1 |  -5.395832   2.537593    -2.13   0.033    -10.36942  -.4222399
          x2 |    12.5627     4.1843     3.00   0.003     4.361623   20.76378
          x3 |   -1.36024   .7521521    -1.81   0.071    -2.834431   .1139514
          x4 |   19.36181   34.27936     0.56   0.572    -47.82451   86.54814
       _cons |  -2.120951   .7741203    -2.74   0.006    -3.638199  -.6037027
------------------------------------------------------------------------------

. est store m1

. fitstat

Measures of Fit for mlogit of y

Log-Lik Intercept Only:       -228.765   Log-Lik Full Model:           -169.696
D(329):                        339.393   LR(8):                         118.138
                                         Prob > LR:                       0.000
McFadden's R2:                   0.258   McFadden's Adj R2:               0.193
ML (Cox-Snell) R2:               0.291   Cragg-Uhler(Nagelkerke) R2:      0.395
Count R2:                        0.826   Adj Count R2:                    0.318
AIC:                             1.074   AIC*n:                         369.393
BIC:                         -1582.178   BIC':                          -71.413
BIC used by Stata:             397.799   AIC used by Stata:             359.393

. mlogit y x1 x2 x3 x4, rrr nolog

Multinomial logistic regression                   Number of obs     =        344
                                                  LR chi2(8)        =     118.14
                                                  Prob > chi2       =     0.0000
Log likelihood = -169.69647                       Pseudo R2         =     0.2582

------------------------------------------------------------------------------
           y |        RRR   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |  (base outcome)
-------------+----------------------------------------------------------------
2            |
          x1 |   .0000113   .0000176    -7.33   0.000     5.39e-07    .000238
          x2 |   7.648287   12.95198     1.20   0.230     .2767565   211.3638
          x3 |   .6431613   .1437108    -1.98   0.048     .4150723    .996589
          x4 |   3.02e+09   2.92e+10     2.26   0.024      17.9777   5.08e+17
       _cons |   2.654909   .8297561     3.12   0.002     1.438859   4.898704
-------------+----------------------------------------------------------------
3            |
          x1 |   .0045354   .0115091    -2.13   0.033     .0000314   .6555767
          x2 |     285701    1195459     3.00   0.003     78.38427   1.04e+09
          x3 |   .2565993   .1930017    -1.81   0.071      .058752   1.120698
          x4 |   2.56e+08   8.79e+09     0.56   0.572     1.70e-21   3.87e+37
       _cons |   .1199176   .0928306    -2.74   0.006     .0262997   .5467833
------------------------------------------------------------------------------
```

```
. margins, dydx(*) predict(outcome(1))

Average marginal effects                          Number of obs     =        344
Model VCE    : OIM

Expression   : Pr(y==1), predict(outcome(1))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   1.421686   .1254557    11.33   0.000     1.175797    1.667574
          x2 |  -.4689856   .2205597    -2.13   0.033    -.9012747   -.0366966
          x3 |    .076435   .0300025     2.55   0.011     .0176312    .1352389
          x4 |  -2.892204   1.321013    -2.19   0.029    -5.481341   -.3030667
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(2))

Average marginal effects                          Number of obs     =        344
Model VCE    : OIM

Expression   : Pr(y==2), predict(outcome(2))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -1.381231   .1317163   -10.49   0.000     -1.63939   -1.123072
          x2 |   .1314409   .2051985     0.64   0.522    -.2707407    .5336224
          x3 |  -.0420846   .0276118    -1.52   0.127    -.0962028    .0120336
          x4 |   2.557803   1.192438     2.15   0.032      .220668    4.894938
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(3))

Average marginal effects                          Number of obs     =        344
Model VCE    : OIM

Expression   : Pr(y==3), predict(outcome(3))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0404542   .0544461    -0.74   0.457    -.1471667    .0662582
          x2 |   .3375448   .1340434     2.52   0.012     .0748246    .6002649
          x3 |  -.0343504   .0224275    -1.53   0.126    -.0783076    .0096067
          x4 |   .3344007   .9642417     0.35   0.729    -1.555478     2.22428
------------------------------------------------------------------------------
```

IIA Test

```
. mlogit y x1 x2 x3 x4 if y!=3, nolog

Multinomial logistic regression                   Number of obs     =        333
                                                  LR chi2(4)        =     104.30
                                                  Prob > chi2       =     0.0000
Log likelihood = -127.92191                       Pseudo R2         =     0.2896

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |  (base outcome)
-------------+----------------------------------------------------------------
2            |
          x1 |   -11.4855   1.565894    -7.33   0.000     -14.5546   -8.416402
          x2 |   2.782226   1.772243     1.57   0.116    -.6913068    6.255759
          x3 |  -.4379965    .224883    -1.95   0.051     -.878759    .0027661
          x4 |   25.09059     9.9404     2.52   0.012     5.607759    44.57341
       _cons |   .9849019   .3154837     3.12   0.002     .3665653    1.603239
------------------------------------------------------------------------------
```

```
. est store m2

. hausman m2 m1, alleqs constant

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       m2           m1         Difference          S.E.
-------------+----------------------------------------------------------------
          x1 |    -11.4855    -11.38892        -.096579        .1937236
          x2 |    2.782226     2.034482        .7477443        .5225672
          x3 |   -.4379965    -.4413597        .0033633        .0253964
          x4 |    25.09059     21.82959        3.260992        2.329136
       _cons |    .9849019     .9764104        .0084915        .0430218
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from mlogit
            B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        1.18
                Prob>chi2 =      0.9464
                (V_b-V_B is not positive definite)

. est restore m1
(results m1 are active now)

. mlogtest, iia

**** Hausman tests of IIA assumption (N=344)

 Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives.

 Omitted |      chi2   df   P>chi2   evidence
---------+------------------------------------
       2 |    -0.416    5     ---     ---
       3 |     1.185    5    0.946   for Ho
----------------------------------------------
 Note: If chi2<0, the estimated model does not
 meet asymptotic assumptions of the test.

**** suest-based Hausman tests of IIA assumption (N=344)

 Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives.

 Omitted |      chi2   df   P>chi2   evidence
---------+------------------------------------
       2 |     3.918    5    0.561   for Ho
       3 |     5.985    5    0.308   for Ho
----------------------------------------------

**** Small-Hsiao tests of IIA assumption (N=344)

 Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives.

 Omitted |  lnL(full)  lnL(omit)    chi2   df   P>chi2   evidence
---------+---------------------------------------------------------
       2 |    -23.257    -20.835   4.842    5    0.435   for Ho
       3 |    -71.684    -66.675  10.019    5    0.075   for Ho
-------------------------------------------------------------------
```

Ordered Probit

```
. oprobit y x1 x2 x3 x4, nolog

Ordered probit regression                         Number of obs   =        344
                                                  LR chi2(4)      =      83.78
                                                  Prob > chi2     =     0.0000
Log likelihood =  -186.8747                       Pseudo R2       =     0.1831

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
```

```
          x1 |  -4.188225   .5882338    -7.12   0.000    -5.341142   -3.035308
          x2 |   1.655992   .8514763     1.94   0.052    -.0128712    3.324854
          x3 |   -.309457   .1150886    -2.69   0.007    -.5350264   -.0838876
          x4 |   9.988274    4.56095     2.19   0.029     1.048976    18.92757
-------------+----------------------------------------------------------------
       /cut1 |  -.2573573   .1566167                     -.5643203    .0496057
       /cut2 |   1.176929   .1853467                      .8136557    1.540202
------------------------------------------------------------------------------
Note: 1 observation completely determined.  Standard errors questionable.

. fitstat

Measures of Fit for oprobit of y

Log-Lik Intercept Only:       -228.765   Log-Lik Full Model:            -186.875
D(338):                        373.749   LR(4):                           83.781
                                         Prob > LR:                        0.000
McFadden's R2:                   0.183   McFadden's Adj R2:                0.157
ML (Cox-Snell) R2:               0.216   Cragg-Uhler(Nagelkerke) R2:       0.294
McKelvey & Zavoina's R2:         0.442
Variance of y*:                  1.793   Variance of error:                1.000
Count R2:                        0.811   Adj Count R2:                     0.261
AIC:                             1.121   AIC*n:                          385.749
BIC:                         -1600.387   BIC':                           -60.419
BIC used by Stata:             408.793   AIC used by Stata:              385.749

. margins, dydx(*) predict(outcome(1))

Average marginal effects                          Number of obs     =        344
Model VCE    : OIM

Expression   : Pr(y==1), predict(outcome(1))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   1.095411   .1286406     8.52   0.000     .8432798    1.347542
          x2 |  -.4331169   .2214318    -1.96   0.050    -.8671152    .0008815
          x3 |    .080937   .0293447     2.76   0.006     .0234225    .1384515
          x4 |  -2.612387   1.181633    -2.21   0.027    -4.928345   -.2964278
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(2))

Average marginal effects                          Number of obs     =        344
Model VCE    : OIM

Expression   : Pr(y==2), predict(outcome(2))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.8404985   .1035632    -8.12   0.000    -1.043479   -.6375183
          x2 |   .3323265   .1715665     1.94   0.053    -.0039376    .6685907
          x3 |  -.0621022   .0227217    -2.73   0.006     -.106636   -.0175684
          x4 |    2.00446   .9160493     2.19   0.029     .2090362    3.799883
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(3))

Average marginal effects                          Number of obs     =        344
Model VCE    : OIM

Expression   : Pr(y==3), predict(outcome(3))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.2549123   .0689232    -3.70   0.000    -.3899993   -.1198254
```

```
          x2 |   .1007904   .0559651     1.80   0.072    -.0088991    .2104798
          x3 |  -.0188348   .0081533    -2.31   0.021     -.034815   -.0028546
          x4 |   .6079268   .3066529     1.98   0.047     .0068981    1.208956
------------------------------------------------------------------------------

. predict one two three
(option pr assumed; predicted probabilities)

. g yhat=1 if one==max(one,two,three)
(37 missing values generated)

. replace yhat=2 if two==max(one,two,three)
(37 real changes made)

. replace yhat=3 if three==max(one,two,three)
(0 real changes made)

. tab y yhat

           |         yhat
         y |         1          2 |     Total
-----------+----------------------+----------
         1 |       251          5 |       256 
         2 |        49         28 |        77 
         3 |         7          4 |        11 
-----------+----------------------+----------
     Total |       307         37 |       344
```

Test Ordered Probit

```
. oprobit y x1 x2, nolog

Ordered probit regression                         Number of obs   =        500
                                                  LR chi2(2)      =     507.50
                                                  Prob > chi2     =     0.0000
Log likelihood = -107.13797                       Pseudo R2       =     0.7031

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   7.080822   .7097408     9.98   0.000     5.689755    8.471888
          x2 |   3.042603   .2735847    11.12   0.000     2.506387    3.578819
-------------+----------------------------------------------------------------
       /cut1 |  -2.195277   .2792163                     -2.742531   -1.648024
       /cut2 |   1.112197   .2129245                      .6948726    1.529521
------------------------------------------------------------------------------
Note: 139 observations completely determined.  Standard errors questionable.

. tab y

          y |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |         35        7.00        7.00
          2 |         94       18.80       25.80
          3 |        371       74.20      100.00
------------+-----------------------------------
      Total |        500      100.00

. g y12=y>1

. g y23=y>2

. tab y y12

           |          y12
         y |         0          1 |     Total
-----------+----------------------+----------
         1 |        35          0 |        35
         2 |         0         94 |        94
         3 |         0        371 |       371
-----------+----------------------+----------
     Total |        35        465 |       500

. tab y y23

           |          y23
         y |         0          1 |     Total
-----------+----------------------+----------
         1 |        35          0 |        35
         2 |        94          0 |        94
         3 |         0        371 |       371
-----------+----------------------+----------
     Total |       129        371 |       500

. probit y12 x1 x2, nolog

Probit regression                                 Number of obs   =        500
                                                  LR chi2(2)      =     186.37
                                                  Prob > chi2     =     0.0000
Log likelihood = -33.635442                       Pseudo R2       =     0.7348

------------------------------------------------------------------------------
         y12 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   7.739885   1.357405     5.70   0.000     5.079421    10.40035
          x2 |   2.807821   .4628369     6.07   0.000     1.900677    3.714964
       _cons |   1.692526   .3759373     4.50   0.000     .9557026     2.42935
------------------------------------------------------------------------------
Note: 0 failures and 220 successes completely determined.

. est store probit12

. probit y23 x1 x2, nolog
```

```
Probit regression                                 Number of obs   =        500
                                                  LR chi2(2)      =     428.07
                                                  Prob > chi2     =     0.0000
Log likelihood = -71.442965                       Pseudo R2       =     0.7497

------------------------------------------------------------------------------
         y23 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    6.94818   .8545812     8.13   0.000     5.273232    8.623129
          x2 |   3.254541   .3574509     9.10   0.000      2.55395    3.955132
       _cons |  -.9891503   .2443752    -4.05   0.000    -1.468117   -.5101836
------------------------------------------------------------------------------
Note: 5 failures and 95 successes completely determined.

. est store probit23

. suest probit12 probit23

Simultaneous results for probit12, probit23

                                                  Number of obs   =        500

------------------------------------------------------------------------------
             |               Robust
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
probit12_y12 |
          x1 |   7.739885   1.259756     6.14   0.000     5.270809    10.20896
          x2 |   2.807821   .4436205     6.33   0.000      1.93834    3.677301
       _cons |   1.692526   .3674281     4.61   0.000     .9723804    2.412672
-------------+----------------------------------------------------------------
probit23_y23 |
          x1 |    6.94818   .8496727     8.18   0.000     5.282853    8.613508
          x2 |   3.254541   .3662897     8.89   0.000     2.536627    3.972456
       _cons |  -.9891503    .244865    -4.04   0.000    -1.469077   -.5092238
------------------------------------------------------------------------------

. test [probit12_y12]x1=[probit23_y23]x1

 ( 1)  [probit12_y12]x1 - [probit23_y23]x1 = 0

           chi2(  1) =    0.26
         Prob > chi2 =    0.6078

. test [probit12_y12]x2=[probit23_y23]x2

 ( 1)  [probit12_y12]x2 - [probit23_y23]x2 = 0

           chi2(  1) =    0.58
         Prob > chi2 =    0.4462
```

<u>Alternative Test</u>

```
. oprobit y x1 x2, nolog

Ordered probit regression                         Number of obs   =        500
                                                  LR chi2(2)      =     507.50
                                                  Prob > chi2     =     0.0000
Log likelihood = -107.13797                       Pseudo R2       =     0.7031

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   7.080822   .7097408     9.98   0.000     5.689755    8.471888
          x2 |   3.042603   .2735847    11.12   0.000     2.506387    3.578819
-------------+----------------------------------------------------------------
       /cut1 |  -2.195277   .2792163                     -2.742531   -1.648024
       /cut2 |   1.112197   .2129245                      .6948726    1.529521
------------------------------------------------------------------------------
Note: 139 observations completely determined.  Standard errors questionable.

. gologit2 y x1 x2, pl sto(oprobit) link(p)

Generalized Ordered Probit Estimates              Number of obs   =        500
```

```
                                                  Wald chi2(2)      =     125.88
                                                  Prob > chi2       =     0.0000
Log likelihood = -107.13797                       Pseudo R2         =     0.7031

 ( 1)  [1]x1 - [2]x1 = 0
 ( 2)  [1]x2 - [2]x2 = 0
------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
          x1 |   7.080822   .7097408     9.98   0.000     5.689755    8.471888
          x2 |   3.042603   .2735847    11.12   0.000     2.506387    3.578819
       _cons |   2.195277   .2792163     7.86   0.000     1.648024    2.742531
-------------+----------------------------------------------------------------
2            |
          x1 |   7.080822   .7097408     9.98   0.000     5.689755    8.471888
          x2 |   3.042603   .2735847    11.12   0.000     2.506387    3.578819
       _cons |  -1.112197   .2129245    -5.22   0.000    -1.529521   -.6948726
------------------------------------------------------------------------------

. gologit2 y x1 x2, npl sto(goprobit) link(p)

Generalized Ordered Probit Estimates              Number of obs     =        500
                                                  LR chi2(4)        =     512.10
                                                  Prob > chi2       =     0.0000
Log likelihood = -104.83593                       Pseudo R2         =     0.7095

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
1            |
          x1 |   7.737641   1.353034     5.72   0.000     5.085742    10.38954
          x2 |   2.802474   .4618616     6.07   0.000     1.897242    3.707706
       _cons |   1.684816   .3762328     4.48   0.000     .9474136    2.422219
-------------+----------------------------------------------------------------
2            |
          x1 |   6.944568   .8518606     8.15   0.000     5.274952    8.614184
          x2 |   3.248837   .3571053     9.10   0.000     2.548924    3.948751
       _cons |  -.9892647   .2433861    -4.06   0.000    -1.466293   -.5122368
------------------------------------------------------------------------------

. lrtest oprobit goprobit, stats

Likelihood-ratio test                                 LR chi2(2)  =      4.60
(Assumption: oprobit nested in goprobit)              Prob > chi2 =    0.1001

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
     oprobit |    500 -360.8862    -107.138      4     222.2759    239.1344
    goprobit |    500 -360.8862   -104.8359      6     221.6719    246.9595
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note.
```