Assignment 10
Multivariate Probit Models

The model

In the study of financing choice, three choices have been studied including capital restructuring, dividend cut, and issue new stock. The probit model can be stated as:

$$I_{Ji} = \beta_{J0} + \beta_{J1}x_{1i} + \beta_{J2}x_{2i} + \beta_{J3}x_{3i} + u_{Ji} \quad (1)$$

and

$$\Pr(Y_{Ji} = 1) = \Phi(I_{Ji})$$

where: I_{Ji} is index variables.

Y_{Ji} is decision to choose financial choice J, value equals to 1 if choosing choice J or 0 if not. *J = 1 for capital restructuring, 2 for dividend cut, 3 for issue new stock.*

x_{ki} is independent variable k.

$\Phi(.)$ is multivariate normal probability distribution function.

u_{Ji} is disturbance term.

Requirements From data file – `assign10.dta`**:**

1. Estimate models for Y_{1i}, Y_{2i}, and Y_{3i} assuming that the probability functions follow separate normal distribution function. Interpret your estimated result (sign and meaning, overall test, pseudo R^2, individual test).
2. Estimate models for Y_{1i}, Y_{2i}, and Y_{3i} assuming that the probability functions follow multivariate normal probability distribution function (MV Probit models). Determine whether MVProbit is appropriated. Why?

By Tatre Jantarakolica

6104641300

```
-------------------------------------------------------------------------------
-------------------------------------------------
      name:  <unnamed>
       log:  C:\Users\User\Desktop\EE 426 stata\assign10 6104641300.log
  log type:  text
 opened on:   8 Apr 2021, 10:31:03

. clear

. use "C:\Users\User\Desktop\EE 426 stata\assign10.dta", clear

. probit y1 x1 x2 x3

Iteration 0:   log likelihood = -45.533775
Iteration 1:   log likelihood =  -35.05321
Iteration 2:   log likelihood = -34.122847
Iteration 3:   log likelihood = -34.092095
Iteration 4:   log likelihood =  -34.09209
Iteration 5:   log likelihood =  -34.09209

Probit regression                                 Number of obs     =         67
                                                  LR chi2(3)        =      22.88
                                                  Prob > chi2       =     0.0000
Log likelihood =  -34.09209                       Pseudo R2         =     0.2513

------------------------------------------------------------------------------
          y1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   2.574932   .7958181     3.24   0.001     1.015157    4.134707
          x2 |  -.5031798    .297949    -1.69   0.091    -1.087149    .0807895
          x3 |   .3449061   .1616015     2.13   0.033      .028173    .6616392
       _cons |  -2.186903   .6334447    -3.45   0.001    -3.428432   -.9453743
------------------------------------------------------------------------------
Note: 1 failure and 0 successes completely determined.

. mfx

Marginal effects after probit
      y  = Pr(y1) (predict)
         =  .36909834
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.      z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |   .9714414      .29574    3.28   0.001   .391805  1.55108   .696478
      x2 |   -.189834      .10927   -1.74   0.082  -.404001  .024333   .376661
      x3 |   .1301223      .06173    2.11   0.035   .009127  .251118   .721375
------------------------------------------------------------------------------

. probit y2 x1 x2 x3
```

```
Iteration 0:   log likelihood = -22.432361
Iteration 1:   log likelihood = -19.734461
Iteration 2:   log likelihood = -19.678976
Iteration 3:   log likelihood = -19.678766
Iteration 4:   log likelihood = -19.678766

Probit regression                                 Number of obs     =         67
                                                  LR chi2(3)        =       5.51
                                                  Prob > chi2       =     0.1382
Log likelihood = -19.678766                       Pseudo R2         =     0.1228

------------------------------------------------------------------------------
          y2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    1.196021   .8449952     1.42   0.157    -.4601389    2.852182
          x2 |   -.1604507   .1166507    -1.38   0.169    -.3890818    .0681804
          x3 |    .1023406   .2083685     0.49   0.623    -.3060541    .5107354
       _cons |    .5275558   .5565448     0.95   0.343     -.563252    1.618364
------------------------------------------------------------------------------

. mfx

Marginal effects after probit
      y  = Pr(y2) (predict)
         =  .91527113
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.      z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |    .1856662      .12471    1.49   0.137  -.058758   .43009   .696478
      x2 |   -.0249078       .0197   -1.26   0.206  -.063525  .013709   .376661
      x3 |     .015887      .03182    0.50   0.618  -.046482  .078256   .721375
------------------------------------------------------------------------------

. probit y3 x1 x2 x3

Iteration 0:   log likelihood = -39.952416
Iteration 1:   log likelihood = -35.846932
Iteration 2:   log likelihood = -35.496676
Iteration 3:   log likelihood = -35.486934
Iteration 4:   log likelihood = -35.486933

Probit regression                                 Number of obs     =         67
                                                  LR chi2(3)        =       8.93
                                                  Prob > chi2       =     0.0302
Log likelihood = -35.486933                       Pseudo R2         =     0.1118

------------------------------------------------------------------------------
          y3 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    1.549326   .6925982     2.24   0.025     .1918581    2.906793
```

① Overall test →

② log-likelihood

③ Individual test

. mfx → Sign & meaning

```
          x2 |    -.33157   .2931093    -1.13   0.258    -.9060538    .2429137
          x3 |   .0952456   .1142564     0.83   0.404     -.128693    .3191841
       _cons |  -1.713771   .5536004    -3.10   0.002    -2.798808   -.6287342
------------------------------------------------------------------------------
```

. mfx → Sign & meaning

```
Marginal effects after probit
      y  = Pr(y3) (predict)
         =  .24481972
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
      x1 |   .4868603      .21595    2.25   0.024   .063601   .91012   .696478
      x2 |  -.1041926      .08805   -1.18   0.237  -.276762  .068377   .376661
      x3 |     .02993      .03593    0.83   0.405  -.040493  .100353   .721375
------------------------------------------------------------------------------
```

2) . mvprobit (y1 x1 x2 x3) (y2 x1 x2 x3) (y3 x1 x2 x3)

```
Iteration 0:   log likelihood = -89.257789
Iteration 1:   log likelihood = -88.984176
Iteration 2:   log likelihood = -88.982664
Iteration 3:   log likelihood = -88.982663

Multivariate probit (SML, # draws = 5)            Number of obs   =         67
                                                  Wald chi2(9)    =      25.03
Log likelihood = -88.982663                       Prob > chi2     =     0.0029

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
y1           |
          x1 |   2.592376   .8023984     3.23   0.001     1.019704    4.165048
          x2 |  -.5314422   .3036422    -1.75   0.080     -1.12657    .0636857
          x3 |   .3491611   .1619024     2.16   0.031     .0318383    .6664839
       _cons |  -2.194319   .6357735    -3.45   0.001    -3.440412   -.9482253
-------------+----------------------------------------------------------------
y2           |
          x1 |   1.221734   .8478931     1.44   0.150    -.4401059    2.883574
          x2 |  -.1557306   .1180077    -1.32   0.187    -.3870215    .0755604
          x3 |   .1054215   .2100288     0.50   0.616    -.3062274    .5170703
       _cons |   .5119029   .5577948     0.92   0.359    -.5813547    1.605161
-------------+----------------------------------------------------------------
y3           |
          x1 |   1.535622   .6913496     2.22   0.026     .1806018    2.890642
          x2 |  -.3542075   .2987204    -1.19   0.236    -.9396887    .2312737
          x3 |   .0956571   .1143892     0.84   0.403    -.1285416    .3198557
       _cons |  -1.691533   .5520363    -3.06   0.002    -2.773504   -.6095614
-------------+----------------------------------------------------------------
```

```
    /atrho21 |   .1028098    .306035     0.34   0.737    -.4970077    .7026274
-------------+----------------------------------------------------------------
    /atrho31 |   .1399288   .2264305     0.62   0.537    -.3038669    .5837245
-------------+----------------------------------------------------------------
    /atrho32 |   .1014794    .268692     0.38   0.706    -.4251472    .6281061
-------------+----------------------------------------------------------------
       rho21 |   .1024491   .3028229     0.34   0.735    -.4597606    .6060328
-------------+----------------------------------------------------------------
       rho31 |   .1390226   .2220542     0.63   0.531    -.2948474    .5253672
-------------+----------------------------------------------------------------
       rho32 |   .1011325   .2659439     0.38   0.704    -.4012578    .5567467
------------------------------------------------------------------------------
Likelihood ratio test of  rho21 = rho31 = rho32 = 0:
             chi2(3) =  .550251   Prob > chi2 = 0.9077

. log close
      name:  <unnamed>
       log:  C:\Users\User\Desktop\EE 426 stata\assign10 6104641300.log
  log type:  text
 closed on:   8 Apr 2021, 10:32:06
-------------------------------------------------------------------------------
-------------------------------------------------
```

For LR-test that $H_0: \rho_{21} = \rho_{31} = \rho_{32} = 0$

$\chi^2_3 = 0.550251$ $\quad Prob > \chi^2 = 0.9077 > 0.05$

$\therefore H_0$ is not rejected at 5% level.

Since the correlation between the error term are not correlated, therefor MV probit model will not be appropriated