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:

$$I_{Ji} = \beta_{J0} + \beta_{J1}x_{1i} + \beta_{J2}x_{2i} + \beta_{J3}x_{3i} + \beta_{J4}x_{4i} + u_{Ji} \quad (1)$$

and

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

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?

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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).

```
. 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.
```

- The estimated result shows that the signs of coefficients of x1 and x3 are positive which means that firms involved with x1 and x3 will likely to choose capital restructuring as probability of y equals to one has the positive relationship with x1 and x3. Vice versa for x2.

- The overall chi squared test is significant so all these independent variables can be used together to explain the dependent variable. Pseudo R2 is highest for this model as compared with others.

- Except for x2, other dependent variables are significant under 95% level of confidence, if looking at each individual test separately.

```
. 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
------------------------------------------------------------------------------
```

- The estimated result shows that the signs of coefficients of x1 and x3 are positive which means that firms involved with x1 and x3 will likely to choose dividend cut as probability of y equals to two has the positive relationship with x1 and x3. Vice versa for x2.

- The overall chi squared test is insignificant so all these independent variables should not be used together to explain the dependent variable. Value of Pseudo R2 of this model is in between other two models.

- All independent variables are insignificant under all level of confidence, if looking at each individual test separately.

```
. 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
          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
------------------------------------------------------------------------------
```

- The estimated result shows that the signs of coefficients of x1 and x3 are positive which means that firms involved with x1 and x3 will likely to choose issue new stock as probability of y equals to three has the positive relationship with x1 and x3. Vice versa for x2.

- The overall chi squared test is significant under 95% level of confidence so all these independent variables can be used together to explain the dependent variable. Pseudo R2 is lowest for this model.

- Except for x1, other independent variables are insignificant under all level of confidence, if looking at each individual test separately.

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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?

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

Iteration 0:   log likelihood = -89.257789
Iteration 1:   log likelihood = -88.984177
Iteration 2:   log likelihood = -88.982664
Iteration 3:   log likelihood = -88.982663

Multivariate probit (MSL, # 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	.5170704
_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	.628106
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
```

As the test of Ho : rho = 0 is accepted, MV probit should not be used. There is no relationship among error terms. As can be seen from the confidence interval, values of all rhos are from negative numbers to positive numbers so they can be zero. Hence, the models should be run separately.