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:

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

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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                                                              ___  ____  ____  ____  ____(R)
                                                             /__    /   ____/   /   ____/
                                                            ___/   /   /___/   /   /___/
                                                              Statistics/Data Analysis
```

1

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1 . 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.

2 . fitstat

Measures of Fit for probit of y1

Log-Lik Intercept Only:      -45.534   Log-Lik Full Model:           -34.092
D(63):                        68.184   LR(3):                         22.883
                                       Prob > LR:                      0.000
McFadden's R2:                 0.251   McFadden's Adj R2:              0.163
Maximum Likelihood R2:         0.289   Cragg & Uhler's R2:             0.389
McKelvey and Zavoina's R2:     0.638   Efron's R2:                     0.290
Variance of y*:                2.763   Variance of error:              1.000
Count R2:                      0.716   Adj Count R2:                   0.321
AIC:                           1.137   AIC*n:                         76.184
BIC:                        -196.711   BIC':                         -10.269

3 . 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

```
4 . fitstat

  Measures of Fit for probit of y2

  Log-Lik Intercept Only:      -22.432   Log-Lik Full Model:         -19.679
  D(63):                        39.358   LR(3):                        5.507
                                         Prob > LR:                    0.138
  McFadden's R2:                 0.123   McFadden's Adj R2:           -0.056
  Maximum Likelihood R2:         0.079   Cragg & Uhler's R2:           0.162
  McKelvey and Zavoina's R2:     0.193   Efron's R2:                   0.130
  Variance of y*:                1.239   Variance of error:            1.000
  Count R2:                      0.910   Adj Count R2:                 0.143
  AIC:                           0.707   AIC*n:                       47.358
  BIC:                        -225.538   BIC':                         7.107

5 . 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

```
6 . fitstat

  Measures of Fit for probit of y3

  Log-Lik Intercept Only:      -39.952   Log-Lik Full Model:         -35.487
  D(63):                        70.974   LR(3):                        8.931
                                         Prob > LR:                    0.030
  McFadden's R2:                 0.112   McFadden's Adj R2:            0.012
  Maximum Likelihood R2:         0.125   Cragg & Uhler's R2:           0.179
  McKelvey and Zavoina's R2:     0.368   Efron's R2:                   0.121
  Variance of y*:                1.583   Variance of error:            1.000
  Count R2:                      0.746   Adj Count R2:                 0.105
  AIC:                           1.179   AIC*n:                       78.974
  BIC:                        -193.922   BIC':                         3.683
```

2

```
7 . findit mvprobit

8 . 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

9 . log close
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LR Test $= 2(-88.98 - (-34.09 - 19.68 - 35.49))$
$= 0.550251$ //

$H_0 : \rho_{21} = \rho_{31} = \rho_{32} = 0$

reject the null hypothesis which implies that multivariate normal proability distribution is superior to seperate normal distribution.