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Assignment 9
MN Logit & Ordered Logit Models

The model

In the study of problems of the business, the most serious problem was the price-war. The analysis is trying to estimate the model that determines factors that have impact on the degree of seriousness of the problem.

$$Prob(y_i=j|X) = f(x_1, x_2, x_3, x_4)$$

where: y_i is categorical data = 0 for no problem, = 1 for less serious, …, and = 5 for very serious, and $i=1$ or 2.
x_1 is dummy variable = 0 for nonfamily firm and =1 for family firm.
x_2 is dummy variable = 0 for no brand and =1 for have own-brand name.
x_3 is dummy variable = 0 for low technology and =1 for high technology firm.
x_4 is log of the size of the firm.

Requirements: From data file – `Assign09.dta`:

1 Estimate the model using multinomial logit of y_i. Perform IIA test. Interpret your estimated result (overall test, individual test, pseudo R^2, counted R^2).

```
. set more off
```

Multinamoial Logit Model

```
. mlogit y x*, b(0)

Iteration 0:   log likelihood = -228.64363
. . .
Iteration 4:   log likelihood = -203.28337

Multinomial logistic regression                 Number of obs     =        152
                                                LR chi2(20)       =      50.72
                                                Prob > chi2       =     0.0002
Log likelihood = -203.28337                     Pseudo R2         =     0.1109

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
0            |  (base outcome)
-------------+----------------------------------------------------------------
1            |
          x1 |  -.1220175   1.086872    -0.11   0.911    -2.252248    2.008213
          x2 |  -2.016388   1.349482    -1.49   0.135    -4.661323    .6285484
```

x3	1.253423	1.23587	1.01	0.310	-1.168837	3.675683
x4	1.307279	.5491571	2.38	0.017	.2309504	2.383607
_cons	-18.06503	8.062973	-2.24	0.025	-33.86817	-2.261896
2						
x1	.9699943	.991428	0.98	0.328	-.9731688	2.913157
x2	-1.631037	1.27855	-1.28	0.202	-4.136949	.8748753
x3	-1.034421	.9547311	-1.08	0.279	-2.905659	.836818
x4	.2042703	.3925818	0.52	0.603	-.5651758	.9737165
_cons	-.9022321	5.40243	-0.17	0.867	-11.4908	9.686336
3						
x1	-.4040394	.938099	-0.43	0.667	-2.24268	1.434601
x2	-.9533924	1.222189	-0.78	0.435	-3.348838	1.442053
x3	-.1658373	.8733107	-0.19	0.849	-1.877495	1.54582
x4	.2174653	.3490812	0.62	0.533	-.4667212	.9016518
_cons	-1.061943	4.802704	-0.22	0.825	-10.47507	8.351185
4						
x1	1.677905	.9300468	1.80	0.071	-.1449532	3.500763
x2	-2.104352	1.212395	-1.74	0.083	-4.480602	.2718986
x3	-1.209535	.8915675	-1.36	0.175	-2.956975	.5379055
x4	.1831672	.3654684	0.50	0.616	-.5331376	.899472
_cons	-.0171095	5.005591	-0.00	0.997	-9.827887	9.793669
5						
x1	1.832363	.8632903	2.12	0.034	.1403452	3.524381
x2	-2.368735	1.168139	-2.03	0.043	-4.658246	-.079224
x3	.0976971	.8455682	0.12	0.908	-1.559586	1.75498
x4	.4905651	.3468626	1.41	0.157	-.189273	1.170403
_cons	-4.204706	4.763082	-0.88	0.377	-13.54017	5.130762

```
. est store mlogit
```

To find Counted R^2

```
. predict zero one two three four five
(option pr assumed; predicted probabilities)
(73 missing values generated)

. gen yhat=0 if zero==max(zero,one,two,three,four,five)
(152 missing values generated)

. replace yhat=1 if one==max(zero,one,two,three,four,five)
(73 real changes made)

. replace yhat=2 if two==max(zero,one,two,three,four,five)
(73 real changes made)

. replace yhat=3 if three==max(zero,one,two,three,four,five)
(111 real changes made)

. replace yhat=4 if four==max(zero,one,two,three,four,five)
(79 real changes made)

. replace yhat=5 if five==max(zero,one,two,three,four,five)
(181 real changes made)

. tabulate y yhat

           |               yhat
         y |         3          4          5 |     Total
-----------+---------------------------------+----------
         0 |         6          0         23 |        29
         1 |         3          0         11 |        14
         2 |         5          1         21 |        27
         3 |        12          1         20 |        33
         4 |         5          2         28 |        35
         5 |         7          2         78 |        87
-----------+---------------------------------+----------
     Total |        38          6        181 |       225
```

<u>To test IIA</u>

```
. qui mlogit y x* if y!=1 , b(0)

. est store mlogit1

. qui mlogit y x* if y!=2 , b(0)

. est store mlogit2

. qui mlogit y x* if y!=3 , b(0)

. est store mlogit3

. qui mlogit y x* if y!=4 , b(0)

. est store mlogit4

. qui mlogit y x* if y!=5 , b(0)

. est store mlogit5


. hausman mlogit mlogit1,alleqs constant


Note: the rank of the differenced variance matrix (19) does not equal the number of coefficients
being tested (20); be sure this is what you expect, or there may be problems

        computing the test.  Examine the output of your estimators for anything unexpected and
possibly consider scaling your variables so that the coefficients are on a

        similar scale.


                 ---- Coefficients ----

             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))

             |     mlogit      mlogit1       Difference          S.E.

-------------+----------------------------------------------------------------

2            |

          x1 |    .9699943     .9262698        .0437245        .1403704

          x2 |   -1.631037     -1.57383       -.0572063        .1145239

          x3 |   -1.034421    -.9679021       -.0665185        .1401712

          x4 |    .2042703     .2039257        .0003446        .0478995

       _cons |   -.9022321    -.9630944        .0608623        .6966699

-------------+----------------------------------------------------------------

3            |

          x1 |   -.4040394     -.408268        .0042286        .1349619

          x2 |   -.9533924    -.9436889       -.0097035        .0864806

          x3 |   -.1658373    -.1574169       -.0084204        .1248587

          x4 |    .2174653     .2145878        .0028775        .0426311
```

```
       _cons |   -1.061943    -1.033873       -.0280695        .6815408
-------------+----------------------------------------------------------------
4            |
          x1 |    1.677905     1.629302        .0486028        .1290677
          x2 |   -2.104352    -2.041595       -.0627569        .1060132
          x3 |   -1.209535    -1.122357       -.0871777        .1284415
          x4 |    .1831672     .1797913        .0033759        .0422583
       _cons |   -.0171095    -.0465668        .0294574        .6384663
-------------+----------------------------------------------------------------
5            |
          x1 |    1.832363     1.787321        .0450417        .1269999
          x2 |   -2.368735    -2.317706       -.0510288        .0760812
          x3 |    .0976971     .1965112       -.0988141        .1130219
          x4 |    .4905651     .4902412         .000324        .0349907
       _cons |   -4.204706    -4.281237        .0765307        .5495838
------------------------------------------------------------------------------
                          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(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.71
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)

. hausman mlogit2 mlogit, alleqs constant

Note: the rank of the differenced variance matrix (19) does not equal the number of coefficients
being tested (20); be sure this is what you expect, or there may be problems
        computing the test.  Examine the output of your estimators for anything unexpected and
possibly consider scaling your variables so that the coefficients are on a
        similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    mlogit2       mlogit       Difference          S.E.
```

```
-------------+----------------------------------------------------------------
1            |
          x1 |   -.2627881    -.1220175       -.1407705        .2437265
          x2 |   -1.967227    -2.016388        .0491607               .
          x3 |     1.42199     1.253423        .1685666        .2658193
          x4 |    1.352602     1.307279        .0453231        .1269411
       _cons |   -18.83634    -18.06503        -.771306        1.982998
-------------+----------------------------------------------------------------
3            |
          x1 |   -.4198932    -.4040394       -.0158538        .1288599
          x2 |   -.8890144    -.9533924         .064378               .
          x3 |    -.129837    -.1658373        .0360002               .
          x4 |    .2090977     .2174653       -.0083676          .04158
       _cons |   -1.017863    -1.061943        .0440796        .9138793
-------------+----------------------------------------------------------------
4            |
          x1 |    1.704966     1.677905        .0270613        .1641796
          x2 |   -2.024298    -2.104352         .080054               .
          x3 |   -1.164247    -1.209535        .0452881        .1026504
          x4 |    .1519007     .1831672       -.0312665        .0637932
       _cons |    .3106285    -.0171095        .3277379        1.097537
-------------+----------------------------------------------------------------
5            |
          x1 |    1.840991     1.832363        .0086281        .1414783
          x2 |   -2.324036    -2.368735        .0446987               .
          x3 |    .1324245     .0976971        .0347274        .0962939
          x4 |    .4649274     .4905651       -.0256377        .0708576
       _cons |   -3.915288    -4.204706        .2894183        1.187887
------------------------------------------------------------------------------
                          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(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                           =        0.47
```

```
                Prob>chi2 =      1.0000

                (V_b-V_B is not positive definite)


. hausman mlogit3 mlogit, alleqs constant


Note: the rank of the differenced variance matrix (19) does not equal the number of coefficients
being tested (20); be sure this is what you expect, or there may be problems

        computing the test.  Examine the output of your estimators for anything unexpected and
possibly consider scaling your variables so that the coefficients are on a

        similar scale.


                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    mlogit3       mlogit       Difference          S.E.
-------------+----------------------------------------------------------------
1            |
          x1 |   -.0345956    -.1220175         .087422               .
          x2 |   -1.944929    -2.016388        .0714583               .
          x3 |    1.008411     1.253423       -.2450125               .
          x4 |    1.173903     1.307279       -.1333753               .
       _cons |   -16.06881    -18.06503        1.996222               .
-------------+----------------------------------------------------------------
2            |
          x1 |    .9993361     .9699943        .0293418        .1540878
          x2 |    -1.54066    -1.631037        .0903772               .
          x3 |    -1.07311    -1.034421       -.0386898        .1356314
          x4 |    .1708932     .2042703       -.0333771               .
       _cons |   -.4976237    -.9022321        .4046085               .
-------------+----------------------------------------------------------------
4            |
          x1 |    1.712027     1.677905        .0341224         .155819
          x2 |   -1.984394    -2.104352        .1199581               .
          x3 |   -1.268538    -1.209535       -.0590035        .1581729
          x4 |    .1397741     .1831672       -.0433931               .
       _cons |    .5172055    -.0171095        .5343149               .
-------------+----------------------------------------------------------------
5            |
```

```
         x1 |     1.81674     1.832363       -.0156229         .090417
         x2 |   -2.242124    -2.368735        .1266108               .
         x3 |    .0269395     .0976971       -.0707576        .1412581
         x4 |    .4149522     .4905651        -.075613               .
      _cons |    -3.16993    -4.204706        1.034776               .
------------------------------------------------------------------------------
                          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(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        2.04
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)

. hausman mlogit4 mlogit, alleqs constant

Note: the rank of the differenced variance matrix (19) does not equal the number of coefficients
being tested (20); be sure this is what you expect, or there may be problems
        computing the test.  Examine the output of your estimators for anything unexpected and
possibly consider scaling your variables so that the coefficients are on a
        similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    mlogit4       mlogit       Difference          S.E.
-------------+----------------------------------------------------------------
1            |
         x1 |    .0295265    -.1220175         .151544               .
         x2 |   -1.973401    -2.016388        .0429865        .1607527
         x3 |    1.207552     1.253423       -.0458709        .1689117
         x4 |    1.243142     1.307279       -.0641366               .
      _cons |   -17.20365    -18.06503         .861379               .
-------------+----------------------------------------------------------------
2            |
         x1 |    1.014523     .9699943        .0445285               .
```

```
          x2 |   -1.652876    -1.631037       -.0218398        .1540759
          x3 |   -1.059433    -1.034421       -.0250125        .1199088
          x4 |     .205666     .2042703        .0013957               .
       _cons |   -.9039178    -.9022321       -.0016857               .
-------------+----------------------------------------------------------------
3            |
          x1 |   -.3555477    -.4040394        .0484917               .
          x2 |    -.953488    -.9533924       -.0000956        .1279901
          x3 |   -.1864263    -.1658373       -.0205891        .1095678
          x4 |    .1988436     .2174653       -.0186217               .
       _cons |   -.8040827    -1.061943        .2578602               .
-------------+----------------------------------------------------------------
5            |
          x1 |    1.917478     1.832363        .0851147        .0639035
          x2 |   -2.399049    -2.368735       -.0303146        .1991226
          x3 |    .0750429     .0976971       -.0226542        .1709826
          x4 |    .4760917     .4905651       -.0144735               .
       _cons |   -4.002073    -4.204706        .2026339               .
------------------------------------------------------------------------------
                          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(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                           =        1.97
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)

.
. hausman mlogit mlogit5, alleqs constant

Note: the rank of the differenced variance matrix (19) does not equal the number of coefficients
being tested (20); be sure this is what you expect, or there may be problems
        computing the test.  Examine the output of your estimators for anything unexpected and
possibly consider scaling your variables so that the coefficients are on a
        similar scale.
```

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	mlogit	mlogit5	Difference	S.E.
1				
x1	-.1220175	-.1485919	.0265744	.
x2	-2.016388	-2.34891	.3325224	.
x3	1.253423	1.214949	.0384741	.
x4	1.307279	1.440948	-.1336696	.
_cons	-18.06503	-19.70723	1.6422	.
2				
x1	.9699943	.8102007	.1597936	.170108
x2	-1.631037	-1.804572	.1735351	.
x3	-1.034421	-1.056176	.0217556	.
x4	.2042703	.2541214	-.0498511	.
_cons	-.9022321	-1.386087	.4838551	.
3				
x1	-.4040394	-.4484998	.0444605	.1637462
x2	-.9533924	-1.067195	.113803	.
x3	-.1658373	-.2305792	.0647419	.0571963
x4	.2174653	.2442322	-.0267669	.
_cons	-1.061943	-1.284649	.2227059	.
4				
x1	1.677905	1.478476	.1994286	.122249
x2	-2.104352	-2.278957	.174605	.
x3	-1.209535	-1.24603	.0364958	.
x4	.1831672	.2456624	-.0624952	.
_cons	-.0171095	-.6496392	.6325297	.

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(19) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                       =        0.92
             Prob>chi2 =      1.0000
             (V_b-V_B is not positive definite)
```

From the Huasman test, it illustrates that the IIA property is being held since the null hypothesis cannot be rejected.

According to the overall test (LR Test), p-value=0.0002 < 0.05, so all independent variables, altogether, can significantly explain the degree of seriousness problem of the price-war.

From the individual test, it suggests that "log of size of the firm" can significantly explain the difference between the firm having no problem and less serious problem; while "the state of being a family firm" and "Having its own brand-name" can significantly explain the different between the firm having no problem and very serious problem.

Psuedo R^2 = 0.1109 which is quite low.

Counted R^2 = (12+2+78)/225 = 0.4089. It implies that the model correctly predict the dependent variable 40.89%.

2 Estimate the model using order logit of y_i. Interpret your estimated result (overall test, individual test, pseudo R^2, counted R^2).

Order Logit Model

```
. ologit y x*

Iteration 0:   log likelihood = -228.64363

. . .

Iteration 4:   log likelihood = -216.23748


Ordered logistic regression                     Number of obs     =        152

                                                LR chi2(4)        =      24.81

                                                Prob > chi2       =     0.0001

Log likelihood = -216.23748                     Pseudo R2         =     0.0543


------------------------------------------------------------------------------

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

-------------+----------------------------------------------------------------

          x1 |    1.26067   .3475145     3.63   0.000     .5795538    1.941786

          x2 |  -.8530234   .3508641    -2.43   0.015    -1.540705   -.1653424

          x3 |   .2068371   .3398536     0.61   0.543    -.4592637    .8729379

          x4 |   .1261028   .1511501     0.83   0.404    -.1701459    .4223515

-------------+----------------------------------------------------------------

       /cut1 |  -.8807685   2.139511                     -5.074134    3.312597

       /cut2 |  -.0328063   2.126237                     -4.200155    4.134542

       /cut3 |   .6557008   2.118367                     -3.496223    4.807624

       /cut4 |    1.48964   2.117389                     -2.660365    5.639646

       /cut5 |   2.283969   2.124223                     -1.879432    6.447371

------------------------------------------------------------------------------

. drop yhat zero one two three four five
```

Counted R²

```
. predict zero one two three four five

(option pr assumed; predicted probabilities)

(73 missing values generated)


. gen yhat=0 if zero==max(zero,one,two,three,four,five)

(152 missing values generated)
```

```
. replace yhat=1 if one==max(zero,one,two,three,four,five)
(73 real changes made)

. replace yhat=2 if two==max(zero,one,two,three,four,five)
(73 real changes made)

. replace yhat=3 if three==max(zero,one,two,three,four,five)
(86 real changes made)

. replace yhat=4 if four==max(zero,one,two,three,four,five)
(73 real changes made)

. replace yhat=5 if five==max(zero,one,two,three,four,five)
(212 real changes made)

. tabulate y yhat
           |         yhat
         y |         3          5 |     Total
-----------+----------------------+----------
         0 |         2         27 |        29
         1 |         0         14 |        14
         2 |         3         24 |        27
         3 |         4         29 |        33
         4 |         2         33 |        35
         5 |         2         85 |        87
-----------+----------------------+----------
     Total |        13        212 |       225
```

According to the overall test (LR Test), p-value= 0.0001 < 0.05, so all independent variables, altogether, can significantly explain the degree of seriousness problem of the price-war.

From the individual test, it illustrates that only the dummy variables of being a family firm and having its own brand-name can significantly explain the degree of seriousness of the price-war problem. Moreover, none of the cuts is significant.

Pseudo R^2 = 0.0543 which is very low.

Counted R^2 = (4+85)/225 = 0.3956. It implies that the model correctly predict the dependent variable 39.56%.

3 From (a) and (b), compare the two models. Perform order logit test. Which model is more appropriated in this case? Why?

Test Ordered Logit

```
. gen y01 = y>0

. gen y12 = y>1

. gen y23 = y>2

. gen y34 = y>3

. gen y45 = y>4

. qui logit y01 x*

. est store logit01

. qui logit y12 x*

. est store logit12

. qui logit y23 x*

. est store logit23

. qui logit y34 x*

. est store logit34

. qui logit y45 x*

. est store logit45

. suest logit01 logit12 logit23 logit34 logit45


Simultaneous results for logit01, logit12, logit23, logit34, logit45


                                                Number of obs     =        152


------------------------------------------------------------------------------

             |               Robust

             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]

-------------+----------------------------------------------------------------

logit01_y01  |

          x1 |   1.097122   .9033857     1.21   0.225    -.6734812    2.867725

          x2 |   -1.82336   1.135405    -1.61   0.108    -4.048713    .4019928

          x3 |  -.3069072    .803698    -0.38   0.703    -1.882126    1.268312

          x4 |   .3527502   .3544918     1.00   0.320    -.3420409    1.047541

       _cons |  -1.099312   4.856106    -0.23   0.821     -10.6171    8.418481

-------------+----------------------------------------------------------------

logit12_y12  |
```

```
          x1 |   1.264527   .5825003     2.17   0.030     .1228478    2.406207
          x2 |  -.7792338    .604258    -1.29   0.197    -1.963558    .4050901
          x3 |  -.8053988   .6052151    -1.33   0.183    -1.991599     .380801
          x4 |  -.2074297   .3082284    -0.67   0.501    -.8115462    .3966868
       _cons |   5.389609   4.422033     1.22   0.223    -3.277416    14.05663
-------------+----------------------------------------------------------------
logit23_y23  |
          x1 |    .864886   .4721274     1.83   0.067    -.0604667    1.790239
          x2 |  -.6170464   .4658079    -1.32   0.185    -1.530013    .2959203
          x3 |  -.0281734   .4629933    -0.06   0.951    -.9356237    .8792769
          x4 |  -.0449685   .2176813    -0.21   0.836    -.4716161    .3816791
       _cons |   1.899683   3.086536     0.62   0.538    -4.149816    7.949182
-------------+----------------------------------------------------------------
logit34_y34  |
          x1 |   1.679889   .4359289     3.85   0.000     .8254838    2.534294
          x2 |  -1.051402   .4339843    -2.42   0.015    -1.901996   -.2008088
          x3 |  -.1154448   .4385046    -0.26   0.792     -.974898    .7440085
          x4 |   .0623465   .1817055     0.34   0.732    -.2937897    .4184826
       _cons |  -.4960081   2.567482    -0.19   0.847     -5.52818    4.536164
-------------+----------------------------------------------------------------
logit45_y45  |
          x1 |   1.213482   .3980963     3.05   0.002     .4332271    1.993736
          x2 |  -.8226954   .3994092    -2.06   0.039    -1.605523   -.0398677
          x3 |    .672316   .4147506     1.62   0.105    -.1405801    1.485212
          x4 |   .2113165   .1907187     1.11   0.268    -.1624853    .5851183
       _cons |  -3.847181   2.713683    -1.42   0.156    -9.165902    1.471539
------------------------------------------------------------------------------
. test [logit01_y01]x1 = [logit12_y12]x1 = [logit23_y23]x1 = [logit34_y34]x1 = [logit45_y45]x1

 ( 1)  [logit01_y01]x1 - [logit12_y12]x1 = 0
 ( 2)  [logit01_y01]x1 - [logit23_y23]x1 = 0
 ( 3)  [logit01_y01]x1 - [logit34_y34]x1 = 0
 ( 4)  [logit01_y01]x1 - [logit45_y45]x1 = 0

           chi2(  4) =    6.95
         Prob > chi2 =    0.1384 >  0.05
```

```
. test [logit01_y01]x2 = [logit12_y12]x2 = [logit23_y23]x2 = [logit34_y34]x2 = [logit45_y45]x2

 ( 1)  [logit01_y01]x2 - [logit12_y12]x2 = 0
 ( 2)  [logit01_y01]x2 - [logit23_y23]x2 = 0
 ( 3)  [logit01_y01]x2 - [logit34_y34]x2 = 0
 ( 4)  [logit01_y01]x2 - [logit45_y45]x2 = 0

           chi2(  4) =    3.24
         Prob > chi2 =    0.5186 >  0.05

. test [logit01_y01]x3 = [logit12_y12]x3 = [logit23_y23]x3 = [logit34_y34]x3 = [logit45_y45]x3

 ( 1)  [logit01_y01]x3 - [logit12_y12]x3 = 0
 ( 2)  [logit01_y01]x3 - [logit23_y23]x3 = 0
 ( 3)  [logit01_y01]x3 - [logit34_y34]x3 = 0
 ( 4)  [logit01_y01]x3 - [logit45_y45]x3 = 0

           chi2(  4) =    8.55
         Prob > chi2 =    0.0734 >  0.05

. test [logit01_y01]x4 = [logit12_y12]x4 = [logit23_y23]x4 = [logit34_y34]x4 = [logit45_y45]x4

 ( 1)  [logit01_y01]x4 - [logit12_y12]x4 = 0
 ( 2)  [logit01_y01]x4 - [logit23_y23]x4 = 0
 ( 3)  [logit01_y01]x4 - [logit34_y34]x4 = 0
 ( 4)  [logit01_y01]x4 - [logit45_y45]x4 = 0

           chi2(  4) =    7.47
         Prob > chi2 =    0.1130 >  0.05

.
```

According to the ordered logit test, the null hypothesis cannot be rejected. Therefore, the ordered logit should be applied. Therefore, The ordered logit model is more appropriated in this case.

4 Compute marginal effect at mean and median of both models.

Marginal Effect at mean and median of MN Logit model

```
. margins, dydx(*) predict(outcome(0))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==0), predict(outcome(0))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   -.049448   .0394996    -1.25   0.211    -.1268658    .0279698
          x2 |   .0953594   .0625156     1.53   0.127     -.027169    .2178878
          x3 |   .0128947   .0388471     0.33   0.740    -.0632443    .0890336
          x4 |  -.0202353   .0163353    -1.24   0.215    -.0522519    .0117814
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(0)) at((median))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==0), predict(outcome(0))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   -.049448   .0394996    -1.25   0.211    -.1268658    .0279698
          x2 |   .0953594   .0625156     1.53   0.127     -.027169    .2178878
          x3 |   .0128947   .0388471     0.33   0.740    -.0632443    .0890336
```

```
          x4 |  -.0202353   .0163353    -1.24   0.215    -.0522519    .0117814
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |  -.0770801   .0429311    -1.80   0.073    -.1612236    .0070633
          x2 |  -.0090692   .0417711    -0.22   0.828    -.0909391    .0728007
          x3 |   .0862353   .0585697     1.47   0.141    -.0285593    .2010298
          x4 |   .0558661     .02814     1.99   0.047     .0007127    .1110196
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |  -.0770801   .0429311    -1.80   0.073    -.1612236    .0070633
          x2 |  -.0090692   .0417711    -0.22   0.828    -.0909391    .0728007
          x3 |   .0862353   .0585697     1.47   0.141    -.0285593    .2010298
```

```
          x4 |   .0558661     .02814     1.99   0.047     .0007127    .1110196
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |   -.010222   .0443173    -0.23   0.818    -.0970824    .0766384
          x2 |   .0162247   .0506471     0.32   0.749    -.0830418    .1154912
          x3 |  -.0705732    .048277    -1.46   0.144    -.1651944    .0240479
          x4 |  -.0146586   .0203981    -0.72   0.472    -.0546381    .0253209
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |   -.010222   .0443173    -0.23   0.818    -.0970824    .0766384
          x2 |   .0162247   .0506471     0.32   0.749    -.0830418    .1154912
          x3 |  -.0705732    .048277    -1.46   0.144    -.1651944    .0240479
```

```
         x4 |  -.0146586   .0203981    -0.72   0.472    -.0546381    .0253209
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |   -.189127   .0587973    -3.22   0.001    -.3043675   -.0738865
          x2 |   .1043358   .0651863     1.60   0.109     -.023427    .2320986
          x3 |   .0071591   .0574438     0.12   0.901    -.1054288    .1197469
          x4 |  -.0209355   .0234814    -0.89   0.373    -.0669581    .0250872
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |   -.189127   .0587973    -3.22   0.001    -.3043675   -.0738865
          x2 |   .1043358   .0651863     1.60   0.109     -.023427    .2320986
          x3 |   .0071591   .0574438     0.12   0.901    -.1054288    .1197469
```

```
         x4 |  -.0209355   .0234814    -0.89   0.373    -.0669581    .0250872
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(4))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==4), predict(outcome(4))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    .077112   .0601692     1.28   0.200    -.0408174    .1950415
          x2 |  -.0337673   .0612127    -0.55   0.581    -.1537419    .0862073
          x3 |  -.1532631   .0608112    -2.52   0.012    -.2724508   -.0340753
          x4 |  -.0312193   .0263643    -1.18   0.236    -.0828923    .0204538
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(4)) at((median))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==4), predict(outcome(4))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    .077112   .0601692     1.28   0.200    -.0408174    .1950415
          x2 |  -.0337673   .0612127    -0.55   0.581    -.1537419    .0862073
          x3 |  -.1532631   .0608112    -2.52   0.012    -.2724508   -.0340753
```

```
          x4 |  -.0312193   .0263643    -1.18   0.236    -.0828923    .0204538
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(5))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==5), predict(outcome(5))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .2487651   .0737675     3.37   0.001     .1041835    .3933467
          x2 |  -.1730834   .0790483    -2.19   0.029    -.3280153   -.0181515
          x3 |   .1175473   .0846921     1.39   0.165    -.0484461    .2835406
          x4 |   .0311825   .0375786     0.83   0.407    -.0424701    .1048351
-----------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(5)) at((median))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==5), predict(outcome(5))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .2487651   .0737675     3.37   0.001     .1041835    .3933467
          x2 |  -.1730834   .0790483    -2.19   0.029    -.3280153   -.0181515
          x3 |   .1175473   .0846921     1.39   0.165    -.0484461    .2835406
```

```
         x4 |   .0311825   .0375786     0.83   0.407    -.0424701    .1048351
------------------------------------------------------------------------------
```

Marginal Effect at mean and median of Ordered Logit model

```
. ologit y x*, nolog

Ordered logistic regression                     Number of obs     =        152
                                                LR chi2(4)        =      24.81
                                                Prob > chi2       =     0.0001
Log likelihood = -216.23748                     Pseudo R2         =     0.0543

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |    1.26067   .3475145     3.63   0.000     .5795538    1.941786
          x2 |  -.8530234   .3508641    -2.43   0.015    -1.540705   -.1653424
          x3 |   .2068371   .3398536     0.61   0.543    -.4592637    .8729379
          x4 |   .1261028   .1511501     0.83   0.404    -.1701459    .4223515
-------------+----------------------------------------------------------------
       /cut1 |  -.8807685   2.139511                     -5.074134    3.312597
       /cut2 |  -.0328063   2.126237                     -4.200155    4.134542
       /cut3 |   .6557008   2.118367                     -3.496223    4.807624
       /cut4 |    1.48964   2.117389                     -2.660365    5.639646
       /cut5 |   2.283969   2.124223                     -1.879432    6.447371
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(0))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==0), predict(outcome(0))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
```

```
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0681609   .0273944    -2.49   0.013     -.121853   -.0144688
          x2 |   .0461206   .0233188     1.98   0.048     .0004166    .0918247
          x3 |  -.0111831   .0186422    -0.60   0.549    -.0477211    .0253549
          x4 |   -.006818   .0084411    -0.81   0.419    -.0233623    .0097263
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(0)) at((median))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==0), predict(outcome(0))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0681609   .0273944    -2.49   0.013     -.121853   -.0144688
          x2 |   .0461206   .0233188     1.98   0.048     .0004166    .0918247
          x3 |  -.0111831   .0186422    -0.60   0.549    -.0477211    .0253549
          x4 |   -.006818   .0084411    -0.81   0.419    -.0233623    .0097263
------------------------------------------------------------------------------

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

Average marginal effects                        Number of obs     =        152
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 |  -.0599322   .0226362    -2.65   0.008    -.1042983    -.015566
          x2 |   .0405527   .0197166     2.06   0.040     .0019088    .0791965
          x3 |   -.009833   .0162697    -0.60   0.546     -.041721     .022055
          x4 |  -.0059949   .0073186    -0.82   0.413    -.0203391    .0083493
------------------------------------------------------------------------------
. margins, dydx(*) predict(outcome(1)) at((median))

Average marginal effects                        Number of obs     =        152
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 |  -.0599322   .0226362    -2.65   0.008    -.1042983    -.015566
          x2 |   .0405527   .0197166     2.06   0.040     .0019088    .0791965
          x3 |   -.009833   .0162697    -0.60   0.546     -.041721     .022055
          x4 |  -.0059949   .0073186    -0.82   0.413    -.0203391    .0083493
-----------------------------------------------------------------------------
. margins, dydx(*) predict(outcome(2))

Average marginal effects                        Number of obs     =        152
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 |  -.0614076   .0202331    -3.04   0.002    -.1010639   -.0217514
          x2 |   .0415511   .0188187     2.21   0.027      .004667    .0784351
```

```
          x3 |  -.0100751   .0166518    -0.61   0.545    -.0427121    .0225619
          x4 |  -.0061425    .007391    -0.83   0.406    -.0206285    .0083435
------------------------------------------------------------------------------
. margins, dydx(*) predict(outcome(2)) at((median))

Average marginal effects                        Number of obs     =        152
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 |  -.0614076   .0202331    -3.04   0.002    -.1010639   -.0217514
          x2 |   .0415511   .0188187     2.21   0.027      .004667    .0784351
          x3 |  -.0100751   .0166518    -0.61   0.545    -.0427121    .0225619
          x4 |  -.0061425    .007391    -0.83   0.406    -.0206285    .0083435
------------------------------------------------------------------------------
. margins, dydx(*) predict(outcome(3))

Average marginal effects                        Number of obs     =        152
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 |  -.0649197   .0193261    -3.36   0.001    -.1027982   -.0270412
          x2 |   .0439275   .0192343     2.28   0.022      .006229     .081626
          x3 |  -.0106513    .017627    -0.60   0.546    -.0451996    .0238969
          x4 |  -.0064938   .0078483    -0.83   0.408    -.0218763    .0088886
```

```
------------------------------------------------------------------------------
. margins, dydx(*) predict(outcome(3)) at((median))

Average marginal effects                        Number of obs     =        152
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 |  -.0649197   .0193261    -3.36   0.001    -.1027982   -.0270412
          x2 |   .0439275   .0192343     2.28   0.022      .006229     .081626
          x3 |  -.0106513    .017627    -0.60   0.546    -.0451996    .0238969
          x4 |  -.0064938   .0078483    -0.83   0.408    -.0218763    .0088886
------------------------------------------------------------------------------
. margins, dydx(*) predict(outcome(4))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==4), predict(outcome(4))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0206373   .0127601    -1.62   0.106    -.0456467     .004372
          x2 |   .0139641   .0092144     1.52   0.130    -.0040958     .032024
          x3 |   -.003386   .0059659    -0.57   0.570    -.0150789     .008307
          x4 |  -.0020643   .0027613    -0.75   0.455    -.0074764    .0033478
------------------------------------------------------------------------------
```

```
. margins, dydx(*) predict(outcome(4)) at((median))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==4), predict(outcome(4))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |  -.0206373   .0127601    -1.62   0.106    -.0456467     .004372
          x2 |   .0139641   .0092144     1.52   0.130    -.0040958     .032024
          x3 |   -.003386   .0059659    -0.57   0.570    -.0150789     .008307
          x4 |  -.0020643   .0027613    -0.75   0.455    -.0074764    .0033478
------------------------------------------------------------------------------

. margins, dydx(*) predict(outcome(5))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==5), predict(outcome(5))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .2750578   .0661191     4.16   0.000     .1454667    .4046489
          x2 |  -.1861159   .0724194    -2.57   0.010    -.3280553   -.0441766
          x3 |   .0451285    .073977     0.61   0.542    -.0998638    .1901208
          x4 |   .0275136    .032782     0.84   0.401    -.0367379    .0917651
------------------------------------------------------------------------------
```

```
. margins, dydx(*) predict(outcome(5)) at((median))

Average marginal effects                        Number of obs     =        152
Model VCE    : OIM

Expression   : Pr(y==5), predict(outcome(5))
dy/dx w.r.t. : x1 x2 x3 x4

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .2750578   .0661191     4.16   0.000     .1454667    .4046489
          x2 |  -.1861159   .0724194    -2.57   0.010    -.3280553   -.0441766
          x3 |   .0451285    .073977     0.61   0.542    -.0998638    .1901208
          x4 |   .0275136    .032782     0.84   0.401    -.0367379    .0917651
------------------------------------------------------------------------------
```